THE YOUNG COLLECTOR

BRITISH FUNGI, LICHENS &c.

BY E. M. HOLMES, F.L.S., F.R.M.S.,
AND PETER GRAY, A.B.S.,

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THE YOUNG COLLECTOR.

BRITISH
FUNGI, LICHENS & MOSSES,

INCLUDING

SCALE-MOSSES AND LIVERWORTS.

BY
E. M HOLMES, F.L.S., F.R.M.S., Etc.,
CURATOR OF THE MUSEUM OF THE PHARMACEUTICAL SOCIETY OF GREAT BRITAIN;
Author of "Mosses, Scale-mosses and Lichens of Devon and Cornwall," and "Botanical Note Book,"
AND
PETER GRAY, A.B.S., Edin.

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FUNGI.

By E. M. HOLMES.

MUSHROOMS, toadstools, the mildew on walls, the mould on bread, the rust on wheat, and the potato disease, are familiar objects to most of us; but few, who are not botanists, are aware that they all belong to the large and varied group of plants comprised under the name of Fungi.

It might be still more surprising to some to learn that the yeast with which bread is made and beer fermented, the vinegar plant which is used to turn sugar and water into vinegar, and the disagreeable skin-disease called ringworm, all belong to the same class of plants. The extent to which some kinds of fungi are used as articles of food in other countries, is probably almost unknown to those who have not lived abroad; for in England mushrooms, and occasionally truffles and morels are almost the only kinds used for culinary purposes.

Many species that would be despised as loathsome toadstools in this country, form regular articles of diet in Italy, Russia, and other continental countries; while in China and Japan several kinds of fungi are cultivated on decaying trunks of trees in the same way that mushrooms are grown in the catacombs of Paris.

It must not be supposed, however, that it is safe to eat cooked toadstools indiscriminately. They differ as much as flowering plants in their properties, some possessing intoxicating and others excessively poisonous qualities; and even species which are usually wholesome appear to become poisonous under exceptional circumstances not yet thoroughly understood. Thus the common mushroom is excluded from the Italian markets as a poisonous plant. Toadstools (the word is here used in the popular sense of the term) should only be eaten on the recommendation of some one who has a thorough knowledge of these plants.

There is, however, one point of view from which the more minute species of fungi are worthy of all the study that can be devoted to them. Important industries, such as the making of beer, wine, vinegar, etc., are dependent for their success upon our knowledge of the conditions under which the minute fungi which are the chief agents in the production of these fluids live and flourish.

Agriculture, also, is largely indebted to careful observation of the development and life history of the microscopic fungi for a knowledge of the causes of the rapid spread of such fungoid growths as the potato disease, the ergot of rye, the smut of wheat, and many others. Some of these fungi are developed in one stage of their life on one plant, and in another stage on a quite different one. Thus a fungus which attacks wheat in an early stage of its development is found later on the berberry, and from the berberry is again communicated to the wheat.

The first step to take in order to gain a knowledge of this important group of plants is to form a collection for examination and study, and to this end a few hints may be useful.

COLLECTING AND PRESERVING FUNGI.

The best places to search for the larger fungi is on the ground under trees, and on decaying stumps in damp, clayey woods and copses. Beech and fir woods on chalky or sandy soil will also yield a large number. Some species may be found in open fields and on mossy banks. From the time that the evening mists arise in early autumn, until the frosts of winter set in, is the best time to look for fungi of the mushroom type. The hardier or more woody species, such as the "sap balls" which grow on the trunks of living trees, may be collected at any time during the year. Many small species which infest dead sticks may be found in good condition in the winter and spring.

Parasitic species, growing on the leaves of living plants, may be met with throughout the spring, summer, and autumn, and are most abundant as a rule on plants of weak vitality, and on those growing under unusual and therefore unfavourable conditions.

A basket, a packet of soft thin paper for wrapping the specimens in, and a pocket-book in which to place leaf parasites, will be found of service; also a few pill or match boxes, to carry small species of moulds or other fungi that would be injured by pressure. The plan usually adopted for preserving the larger and more succulent fungi is to cut a thin slice right through the middle, from the top of the cap to the base of the stem, and to lay this on a piece of blotting paper together with the two halves of the cap or pileus, from which the gills or tubes have previously been removed, until slightly dried, and then to press them slightly between botanical drying paper until they have lost their moisture, the paper being changed every day until the plants are quite dry. The central slice may then be gummed on to white paper, and the two halves of the cap gummed beside it. The section will show the mode of attachment of the gills, the solidity or hollowness of the stem, the ring, and the remains of the wrapper or volva, if any be present.

Small specimens on dead sticks may be preserved by cutting the stem in half longitudinally, and mounting on paper in the same manner. A very convenient plan, however, is to gum them into small white cardboard sliding boxes, similar in shape to match-boxes, and to arrange them edgewise in drawers in alphabetical order, the name being written on the edge of the box, and the date, locality, and collector's name on the outside. Fungi parasitical on leaves may be enclosed in envelopes of uniform size, labelled at their upper edge, and placed alphabetically in drawers.

CLASSIFICATION.

Fungi as a class are distinguished from other plants by growing upon, and deriving their nourishment from, matter in a state of decay or change, or by growing parasitically upon living plants or animals, and producing injurious changes in them. A few of the smaller species bear a considerable resemblance to certain lichens, but they are always of a more evanescent character, soon perishing, while lichens continue to grow year after year.

Fungi may be classed into two principal divisions, according to the mode of their reproduction.

Like other flowerless plants, fungi are reproduced by minute cells called spores, which do not, as seeds do, contain a miniature plant or embryo in their interior. These spores may be easily seen by placing the cap of a full-grown mushroom, separated from the stem, with the gills downward, on a piece of white paper, when, after a few hours, the paper will be seen to be marked with purplish lines corresponding to the gills. A little of this deposit scraped off and placed under a microscope will be found to consist of the spores, which are attached by minute stalks to large cells on the surface of the gills and from which they easily become detached.

In the morel and the pretty little scarlet cup-shaped fungus formed on dead sticks in winter the structure is different. If a thin slice made vertically through the cup be placed in a little water on a slide under the microscope, it will be seen to consist chiefly of a number of small bags (*asci*) containing spores. In this case, therefore, the spores are not free on the surface, and are distinguished by the name of *sporidia*.

It will be readily understood, therefore, that although there may be many fungi which can be easily distinguished by the naked eye, there are others which can only be named by the aid of a microscope. The first of the two principal classes above described is divided into four sub-classes, all of which have the spores exposed on the spore-bearing surface (*hymenium*). The second class comprises two sub-classes, both of which have the spores enclosed in spore-cases (*asci*). These are as follows:—

DIVISION I.

SPORIFERA.

1. *Hymenomycetes.*—This group comprises a very large number of plants similar in habit to the common mushroom, in which the spores cover the surface of gills, tubes, bristles, or a plain surface.

2. *Gasteromycetes.*—In this group the spore-bearing cells line a surface which is not exposed to the air until the plant bursts in decay. Of this group the puff balls may be taken as a type.

3. *Coniomycetes.*—In these plants, when mature, the spores largely exceed in bulk the vegetative organs, and consequently give the appearance of spots of dust of a yellowish brown or other colour to the leaves, etc., on which they grow, whence their name of *Coniomycetes*, or Dust fungi. Of this group, the rust and bunt of corn are an illustration.

4. *Hyphomycetes.*—In this group, on the contrary, the filamentous or thread-like character of the plants are their most obvious feature. Some of the moulds and mildew belong to this section.

DIVISION II.

SPORIDIIFERA.

5. *Physomycetes.*—These consist chiefly of moulds and mildews, but differ from the *Hyphomycetes* in having the spores (*sporidia*) enclosed in spore cases (*asci*).

6. *Ascomycetes.*—This group includes some fungi which in

shape resemble some of the *Hymenomycetes*, and others, very varied in character, but all distinguished by having the spores (*sporidia*) enclosed in spore cases (*asci*).

The distinctions between these groups will, perhaps, be better understood by illustrating them by a reference to the species under each group which are most commonly to be met with.

HYMENOMYCETES.

This sub-class includes several well-marked groups which, nevertheless, run insensibly into each other through intermediate forms.

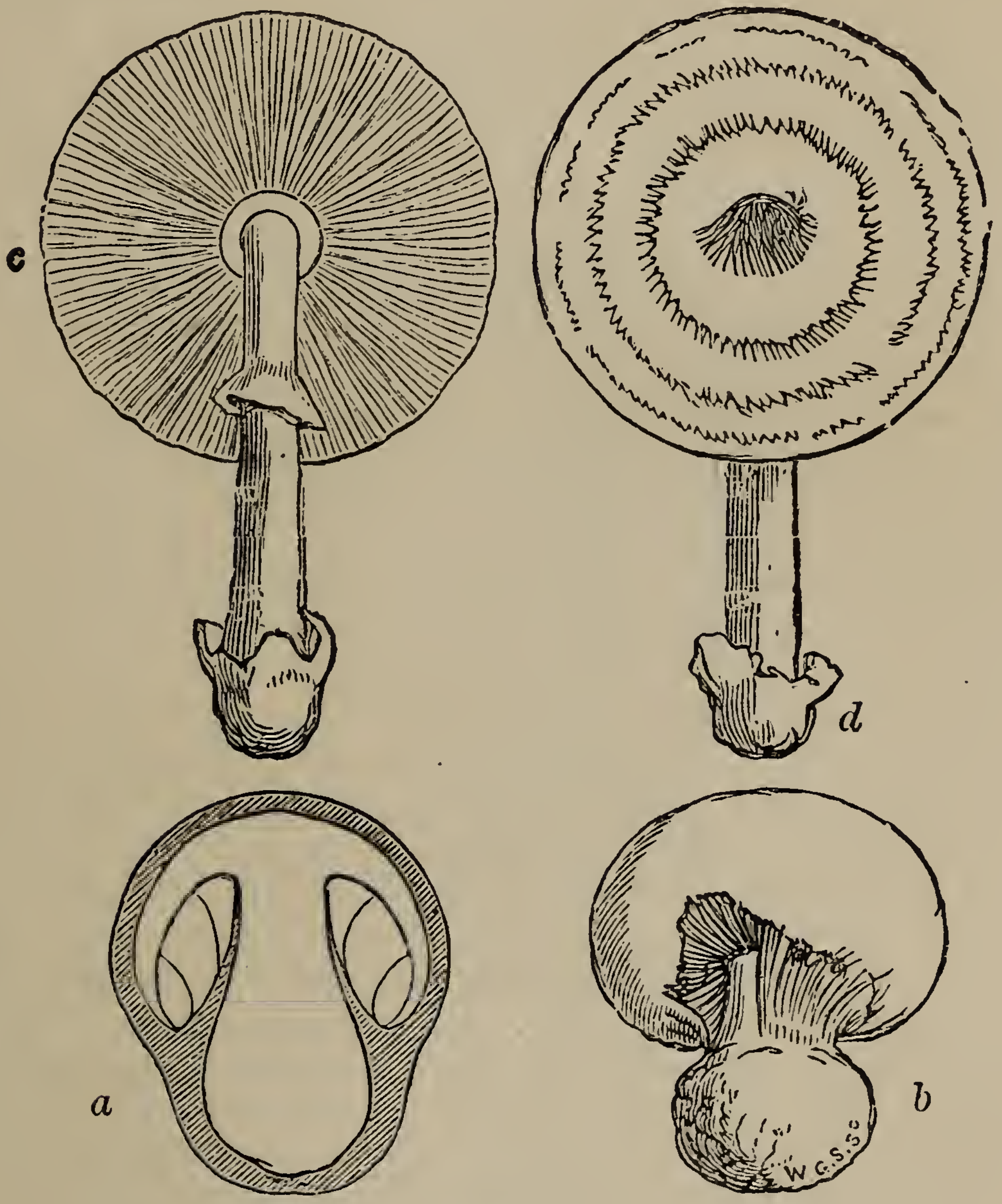

Fig. 1.

The first of these, **Agaricini**, is by far the most extensive; the fungi belonging to it are called Agarics; they bear a general resemblance to the common mushroom.

A brief explanation of the structure of the mushroom will show the distinctive characters of this group.

In the earth underneath the spot where mushrooms appear there will be found a white fibrous matter, like a mass of cottony threads. This is the spawn or *mycelium*, and from this the complex organ bearing the spores arises in the shape of a small, somewhat pear-shaped ball (fig. 1*a*), which soon expands and exhibits a distinct stem, bearing at its summit a more or less hemispherical cap or *pileus*. Before complete expansion the margin of the cap will be found to be joined to the stem (fig. 1*b*), and as the cap increases in size it leaves a thin ring (*annulus*) (see fig. 2*a*) of tissue attached to the stem. The under surface of the cap is covered with numerous flat plates or gills, on which are borne the spores (fig. 1*c*). This is the general character of all the Agarics. In some there is an external layer inclosing the young fungus, and known as the wrapper or *volva* (fig. 1*a*) which becomes ruptured during growth, leaving the lower portion attached to the stem in the form of a cup, or of separate scales, while the upper part is carried upwards on the surface of the cap, and is split up by the increasing size of the latter into warts or scales (fig. 2).

These warts are well seen in the Fly Agaric (*Amanita muscaria*), a handsome species found usually under birch trees, with a scarlet cap and white warts, white gills, and a white stem tapering upwards, an evident ring, and scales at the base of the stem. There is another common species with a whitish cap and warts, which turns pink when bruised, and which is called *A. rubescens*.

The Agarics are chiefly distinguished by the colour of the spores, the brittle or tough, hollow or solid character of the stem, and the way in which the gills are attached to the stem. Sometimes these are fixed to the stem by their whole depth (adnate); sometimes, owing to their tapering to the stem, they only touch it by a small portion of their depth (adnexed); sometimes similarly, but with a point running down the stem, so that the gills appear notched at the end next to the stem (sinuate); and sometimes the gills not only touch the stem, but run down it for a short distance (decurrent), or do not touch it all (free). The spores may be white, pink, brown, purplish, or black. The colour is easily determined by placing the cap or pileus, after removal from the stem, with the gills downwards, on a piece of white paper, when the spores will, after a few hours, form coloured lines on the paper corresponding to the gills. The colour of the spores must not be judged by the colour of the gills, although many of the white-spored species have white gills.

Thus *Clitocybe laccatus*, a pretty pale purple species, with a waxy appearance, rather thick gills of the same colour, and a cap depressed in the centre, and only about half the size of the mushroom, has white spores.

Armillaria melleus, a common species growing on stumps, and of a honey-yellow colour, having a well marked ring, and a cap marked with blackish scales, and *Collybia velutipes*, an agaric of similar colour, but with a tough velvety black stem without a ring, have also white spores.

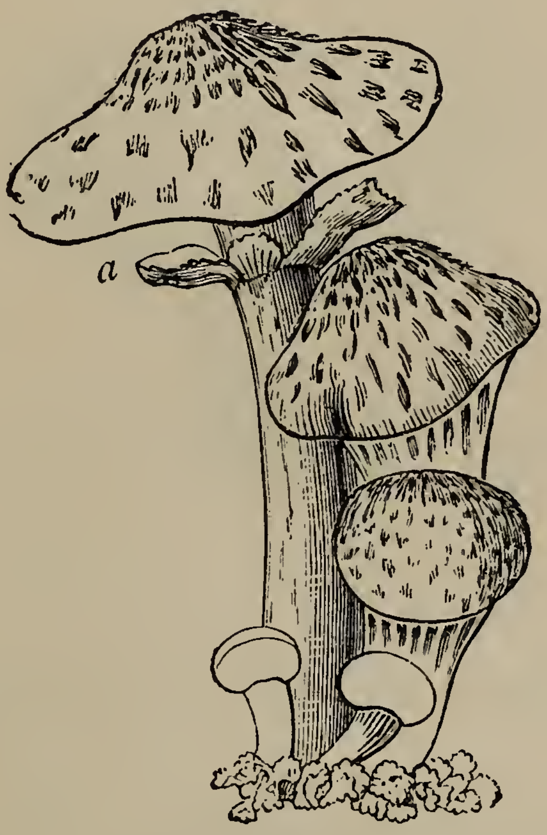

Fig. 2. *Armillaria melleus* (reduced).

The small, brilliant scarlet *Hygrophorus coccineus*, common in pastures, with a conical waxy brittle pileus, has white spores.

There is a small genus of Agarics with white spores, *Cantharellus*, which are remarkable for their thick, somewhat distant, decurrent gills. One of the commonest of them, *C. cibarius*, is an edible species found in woods, the cap is somewhat funnel shaped and of a beautiful egg-yellow colour. It has an odour resembling apricots. The other species of the genus vary in colour, but all have white spores.

Another genus, *Lactarius*, is easily distinguished by exuding a milky juice when broken. One of these, *L. deliciosus*, not unfrequent in fir woods, has a brownish, zoned, nearly flat or slightly depressed cap, reddish decurrent gills, and orange-red milk, which turns green when the gills are bruised. Another species, *Lactarius vellereus*, with a cap often six inches in diameter, depressed in the centre, and of dirty-white colour, is very common in woods.

Somewhat similar in habit, with almost undivided gills, but without milk, is the genus *Russula*. These have mostly short stems, and often a bright red cap, and a peppery or burning taste : many of them are very poisonous.

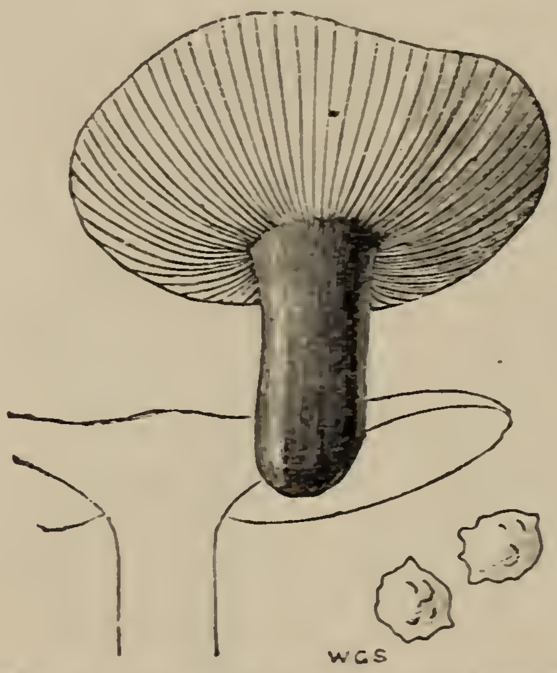

Fig. 3. *Russula rosacea* (reduced).

The remainder of the Agarics with white spores are of a tougher and more persistent character. The fairy ring Champignon, *Marasmius oreades*, which forms, by its outward circular mode of growth, the well-known fairy rings in pastures, does not readily rot like most Agarics, but dries up. This is still more the case with a small species, *Panus stypticus*, with a very short stalk, found growing in small clusters on stumps, and in *Lenzites betulina*, a common stalkless species, also found on stumps. The consistence of the latter plant is quite tough and leathery, or almost woody, and were it not for the evident gills, would be placed in the next section, to which, indeed, it approaches in the zoned upper surface, and in the fact that gills near the point of attachment become united to each other, so as to form irregular tubes.

Of the group with pink spores, one of the commonest species, met with in woods from June to October, is *Clitopilus prunulus*, which has a somewhat waxy cap, 2 to 5 inches broad, and

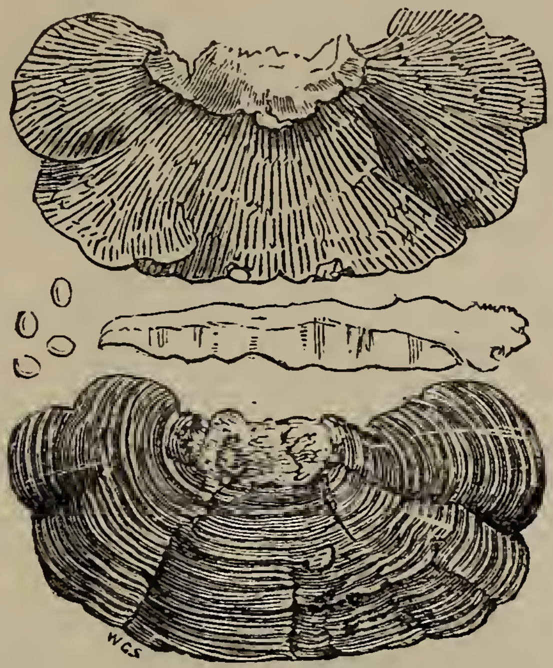

Fig. 4. *Lenzites betulina* (reduced).

whitish or flesh coloured gills; the whole plant has an odour of new meal. The stem is an inch or more high and half an inch broad.

Of the group with brown spores, *Pholiota squarrosa* may be taken as a type. It has a rich tawny yellow colour, and is covered with reflexed scales. It grows in tufts at the roots of trees or near stumps; and differs from *Armillaria melleus* in the absence of a ring and the more convex cap.

Another species, *Stropharia æruginosa*, belonging to this group, and found in woods, is easily recognised by the remarkable green colour and slimy surface of its cap. Another, a small species, *S. semiglobatus*, by the exactly hemispherical shape of the cap; and a third, still smaller, *Psilocybe semilanceata*, called the liberty cap fungus, from the peculiar shape of the cap. The last-named species is very poisonous. A large genus, belonging to the group with brownish spores, is named *Cortinarius*, from the presence of a delicate fibrous veil (cortina) covering the cap, and attached at first to the stem.

The species here represented (fig. 5) is *Cortinarius fulgens*. The stem is woolly, bulbous at the base, and the gills are crowded; the flesh is of a tan colour.

The common mushroom, *Psalliota campestris*, furnishes an illustration of the purple-spored group. It may be distinguished by the pink colour of the gills, turning to brownish black at maturity, by the well-known odour, and the ease with which the epidermis can be peeled off the cap. It prefers open meadow-land.

Of the group with black spores, one of the best known is the *Coprinus comatus*, which has an egg-shaped pileus when young, but which becomes bell-shaped when older, and furrowed at the circumference, and often splits longitudinally; in most of the species the gills melt when mature into a blackish fluid, like ink.

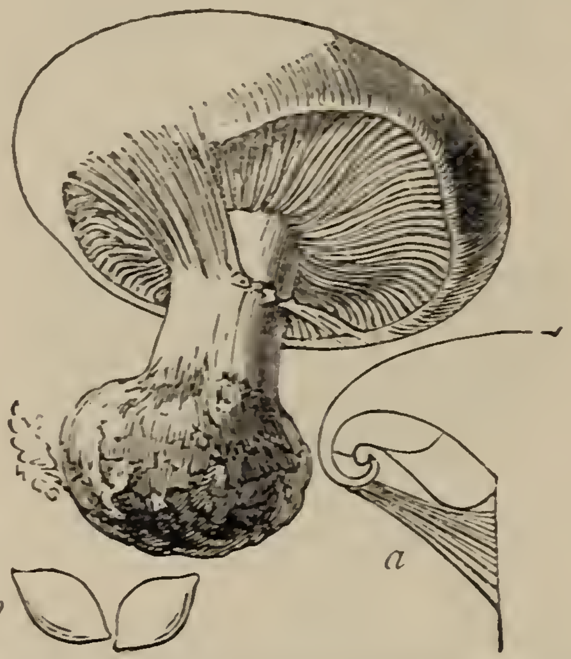

Fig. 5. *Cortinarius fulgens* (reduced).
a. veil, or cortina. *b.* spores, magnified.

Polyporei (many-pored.)—This is the second division of the *Hymenomycetes*, and is very well marked, many of the species resembling the Agarics in outward form, but differing in having the under surface of the caps covered with densely packed tubes instead of gills.

The species of the genus *Boletus* have usually a rounded cap of a brown or yellow colour, and often a very stout stem, which is in some kinds brightly coloured. The flesh of several Boleti turns blue almost immediately when broken. An edible species, *B. edulis*, is one of the earliest to be met with in August or September, and like many of the Agarics grows among dead leaves in woods. Its flesh does not change colour.

The genus *Polyporus* consists largely of tough or woody stemless fungi, many of which grow on living trees. *P. squarrosus*, a white scaly species, is not uncommon on ash trunks, and has a short lateral stem. *P. dryadeus*, frequently met with at the foot of old oak trees, is a stemless species which distils on its surface drops of glutinous moisture.

P. igniarius, is a thick, woody, brown species, shaped like a horse's hoof, but larger, and it is common on plum trees. When beaten soft and cut into layers, it forms amadou, the material formerly employed for tinder, and now used for making brown corn plaisters. *P. versicolor*, is one of the commonest of the stemless species found on old stumps, growing in a crowded manner, and is easily recognised by the bluish grey zones which mark its upper surface.

In *Dædalea quercina*, a stemless species, common on old oak posts and stumps, with a very thick pileus flat at the top and tapering below, the substance is quite hard and woody, and the pores are large and distant from each other.

Merulius lachrymans, better known as the "dry rot," belongs to this group. It is quite different in appearance from all the preceding, being soft and fibrous and spongy, and extending for several feet in cellars and hollow trees; it is often covered with drops of moisture. It often does much damage to timber where it occurs.

A very remarkable edible species is *Fistulina hepatica*. It is found growing inside or on the hollow trunks of old oaks. It resembles in shape, when young, the tongue of an animal, and the flesh when broken is red and juicy. The tubes on the under surface are yellowish and closed, but ultimately separate from one another, so as to approach the next group in character. In all the *Polyporei* the spores line the interior of the tubes.

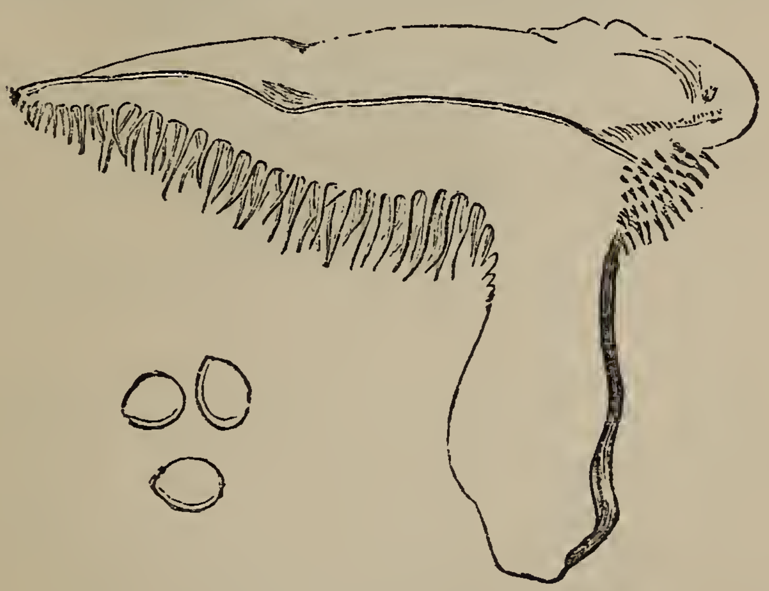

Fig. 6. *Hydnum repandum* (reduced).

The third division of the *Hymenomycetes*, named **Hydnei,** are distinguished by having the under surface of the caps covered with spines instead of gills or pores, the spores being borne on the surface of the spines. There are but few British species. One of the commonest, *Hydnum repandum*, is edible. It is of a cream colour, and has a flat or somewhat depressed cap about the size of, or rather smaller than, that of the mushroom. It may be found in damp woods in autumn. Another, but much smaller, delicate species, of a dark greyish tint, is found on decaying fir cones. It has a slender stem attached to one side of the cap.

In the fourth division, **Auricularini,** the spore-bearing surface is reduced to minute bristles, scarcely visible to the naked eye. One of the most common of this group is *Stereum hirsutum*, a small tough, yellowish, waxy fungus, growing horizontally in clusters out of old stumps. The upper surface is hairy, the under surface smooth. *S. sanguinoleutum*, a thinner species, with a white margin, and *S. rugosum*, a rigid plant, and of a bright brown colour, bleed when wounded, exuding a red juice.

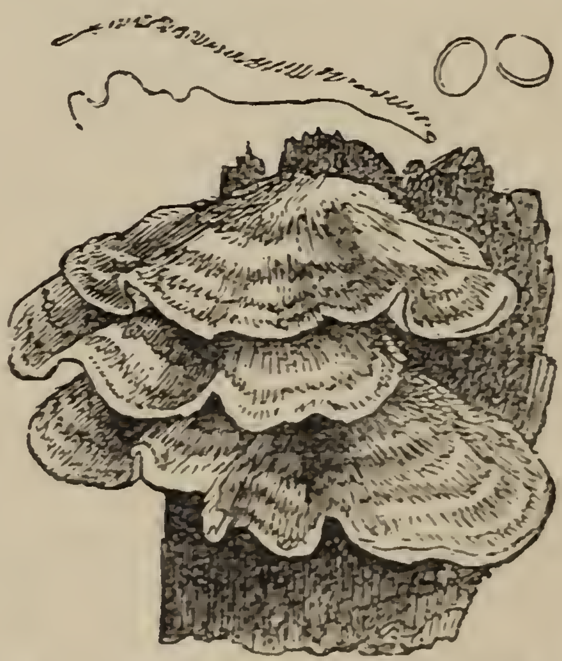

Fig. 7. *Stereum hirsutum* (natural size).

Another fungus, *Corticium cæruleum*, belonging to this group, is remarkable for its deep indigo blue colour. It forms a sort of membranous growth, with cottony edges, on dead sticks or old rails. The species of this genus are common on dead branches, different species as a rule growing on different trees. In all the *Hymenomycetes* hitherto described, the spore-bearing surface is situated underneath the cap, except in *Corticium*, which, by reason of its mode of growth, bears its spores on the upper surface.

In the fifth division, however, many of the plants are club-shaped and cylindrical, whence the name of **Clavariei,** applied to them. Some, however, are branched and coral-like in habit. In all the species the spore-bearing layer covers the external surface. The Clavarias are usually found amongst grass on lawns or pastures, and are mostly of a yellowish white or orange colour, and many of the species are very brittle.

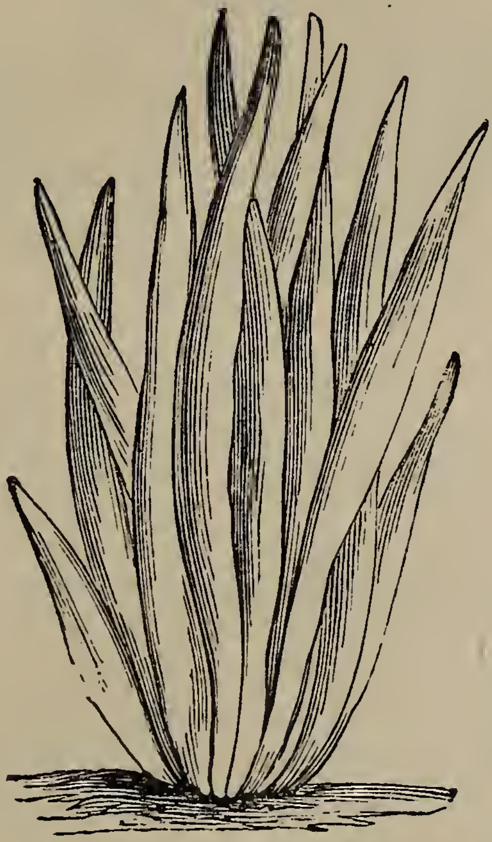

Fig. 8. *Clavaria fusiformis* (natural size).

In the sixth division, **Tremellini,** the substance of the plant is of a more or less gelatinous character, and the spores are borne on the surface. One species, *Tremella mesenterica,* is very common, and after rain forms small masses of tremulous, wavy, orange jelly, on cross-bars of palings and on fallen dead branches in woods. In dry weather it shrinks up and becomes much less conspicuous.

The curious fungi known as "witches' butter" (*Exidia glandulosa*), which forms irregular, purplish, gelatinous patches on dead branches of oak, belongs to this group, as does also the singular plant known as the Jew's-ear fungus, *Hirneola auricula-Judæ.* The latter species is common on old elder trees, in damp places, and bears some resemblance in shape to a human ear. When moist it is soft and velvety to the touch, but is hard and horny when dry. The outer surface is downy, and the inner has a kind of bloom upon it, due to the presence of the spores. A nearly allied species is highly prized by the Chinese as food, who import it from New Zealand and elsewhere in large quantities, as much as 100 tons yearly being often sold in China.

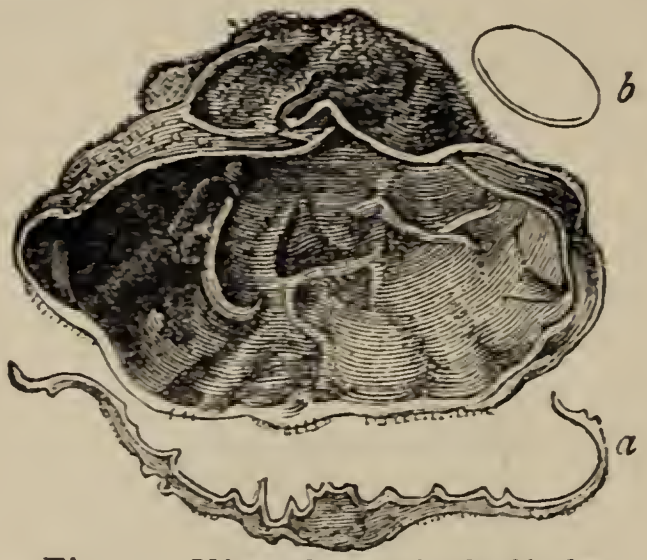

Fig. 9. *Hirneola auricula-Judæ.*
a. vertical section of plant. *b.* spore magnified.

GASTEROMYCETES.

This sub-class is a very small one compared with the *Hymenomycetes*, but contains several very curious plants. The common puff-ball, *Lycoperdon pyriforme,* may be taken as a typical form of the **Trichogastres** group. This plant, when young, is pear-shaped, and appears to consist of a uniform white flesh throughout, but as it becomes older a considerable portion of

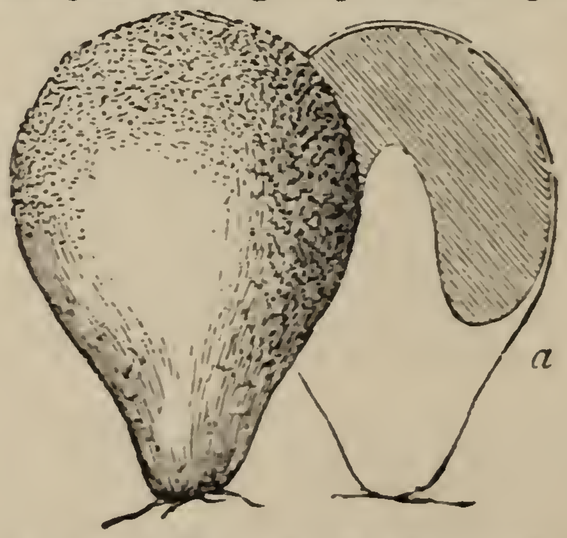

Fig. 10. *Lycoperdon pyriforme.*
a. Longitudinal section ; the dark lines indicate the mass of spores.

the interior is changed into a dusty mass of threads and spores, which are set free by the bursting of the outer coat, or *peridium*, at the apex, from which on the slightest pressure the spores are ejected in a small cloud. Most of the British species of this genus are figured in *Science Gossip*, 1867, p. 270.

Another allied but much rarer plant is the star puff-ball

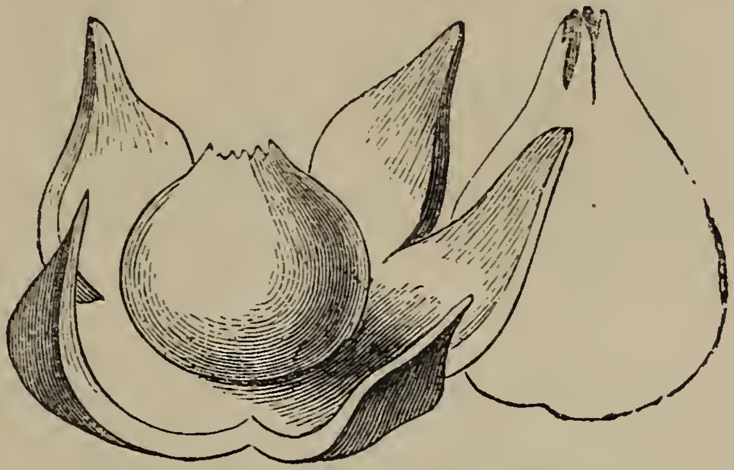

Fig. 11. *Geaster lageniformis.*

(*Geaster*), of which there are several species known to occur in Great Britain. In this genus there is a double coat, the outer one splitting at maturity, and spreading on the ground in the form of a star. The species here figured is *Geaster lageniformis.* Another common fungus, of a globular shape, with a rather thick, warty outer coat, is called *Scleroderma vulgare.* A very remarkable species, belonging to the group **Phalloidei,** is the common stinkhorn (*Phallus impudicus*), which may be found in woody places on sandy soil, in early autumn. When young it has the shape and size and colour of a small hen's egg, with a white fibrous root at its base. It grows very rapidly, and the inclosing membrane on bursting leaves a sort of sheath at the base, from which a porous white stem arises, which bears at its summit a conical cap covered with a greenish slime or jelly, which contains the spores. The odour is extremely disagreeable, but more readily perceptible in a still atmosphere or in a closed room than in the open air.

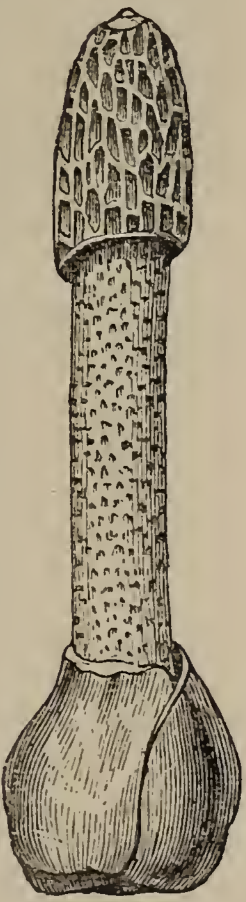

Fig. 12. *Phallus impudicus*(reduced).

A small group of the *Gasteromycetes*, known as the **Myxogastres,** is remarkable for the creamy or pasty consistence of many of the plants in the young state. *Spumaria alba*, which often grows on grass, looks something like cuckoo spit, but in a few days runs to a mass of dark-coloured spores. *Æthalium vaporarium* in like manner forms creamy yellow masses or cocoa-fibre or wood and in greenhouses, which becomes after a few days a mass of yellow spores. In many species of this group, as in *Stemonitis fusca*, a small species growing on rotten wood, the spores are supported by a sort of fibrous skeleton, the delicate fibres of which retain the form of the plant after the dispersion of the spores, and are called *flocci*.

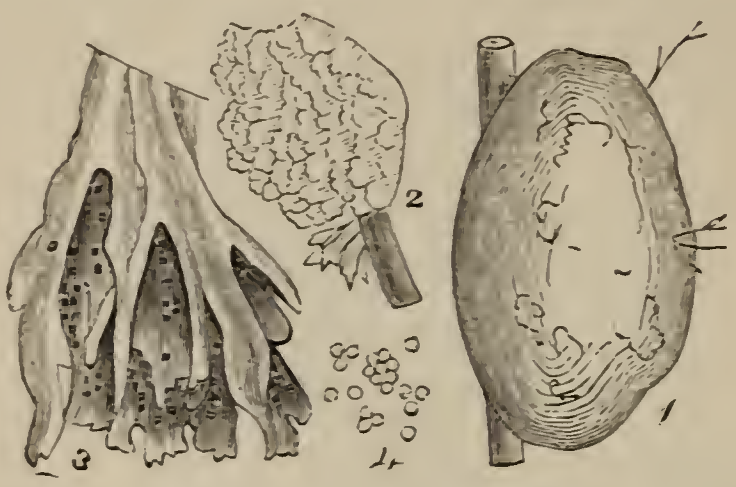

Fig. 13. *Spumaria alba.*
1. Before the escape of the spores. 2. after bursting. 3. skeleton magnified.
4. Spores.

There is one very remarkable little plant, *Cyathus striatus*, belonging to another group of the Gasteromycetes, named **Nidulariacei,** which should not be left unnoticed. It consists of little greyish thimble-shaped bodies, about half an inch high and one-third of an inch broad at the top, which grow in clusters on decaying fir-wood, immersed just below the surface of the earth the wider end being upwards. At first closed by a whitish membrane, it soon becomes open, and discovers a number of small nearly flat bodies placed like eggs in a nest. These consist of masses of stalked spores, each of the little bodies being attached to the walls by an elastic cord.

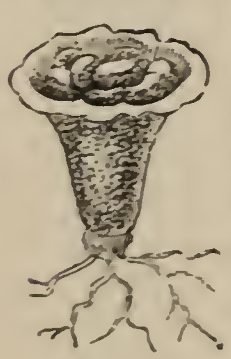

Fig. 14. *Cyathus vernicoscus.*

Another species (*Cyathus vernicoscus*), found in stubble fields, has a smooth cup and darker spore masses. *Crucibulum vulgare*, a small brownish species, may frequently be found on old stems of the bracken fern (*Pteris aquilina*).

CONIOMYCETES (Dust Fungi).

This division comprises two tolerably distinct groups, both, however, characterised by the fact that the spores form the largest proportion of the plant. The one group consists of more or less dusty or sooty patches or dots, growing on dead stems or wood. The life history of many of these has been traced out, and they have been found to be only forms of reproduction belonging to other fungi. The red mould of cheese (*Torula Sporendonema*) belongs to this group.

The other group consists of species parasitic on living plants. They are remarkable for undergoing two or three stages of development, and presenting two or three forms of fructification. Their appearance is so different at different times of the year, that they are not easily recognisable as being the same species. One stage of their life is often commenced on one plant, and finished on another of an entirely different natural order. Thus one species in one stage of its life forms irregular yellow gelatinous cylindrical masses on the stems of the juniper, and receives the name of *Podisoma juniperi*, and in another stage forms brown tufts of horn-shaped tubes containing brown spores, on the hawthorn, and passes under the name of *Ræstelia lacerata*.

During the last few years the different stages of growth of many species have been made out by experimental cultivation of the spores, but as this has not been done in all the species, it will be easier for the young collector, at first, to name and arrange the plants as if they were independent species, and to subsequently place those together which are known to be related to each other, when he is able to make sure of their relationship.

Of this group the cluster cups, or *Æcidiacei*, consist of small yellow, swollen, more or less circular spots, usually on the under side of leaves, and are seen when examined under a lens to consist of clusters of minute, often toothed, cups, and to con-

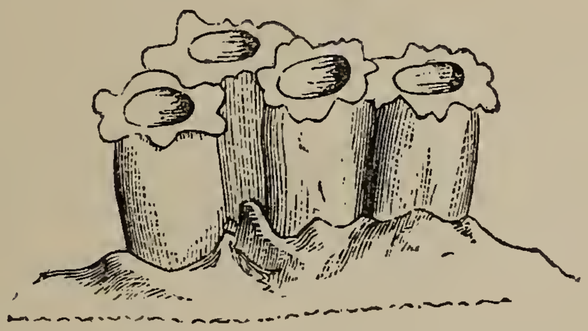

Fig. 15. *Æcidium Berberidis.*

tain nearly globular, yellow, or sometimes white spores, resembling pollen. These fungi may be found from April to June on a great number of plants, each kind of cluster cups being often confined to a single species of flowering plant, or occurring on different species of the same genus, although sometimes met with also on different plants of different genera but of the same natural order. Some of the species (e.g. *Æcidium Berberidis*), have been proved to give rise to fungi classed under the *Pucciniæi*. In the latter group the spores appear chiefly as

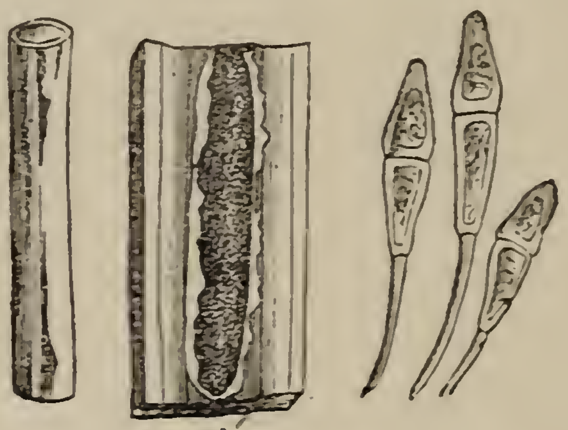

Fig. 16. *Puccinia graminis.*
a. Stem of grain showing appearance of fungus. *b.* ditto, magnified. *c.* spores.

brownish or blackish spots on leaves, in which no cups are visible, such as are present in Æcidium, and the spores are divided into two or more segments. The Puccinias are in some cases

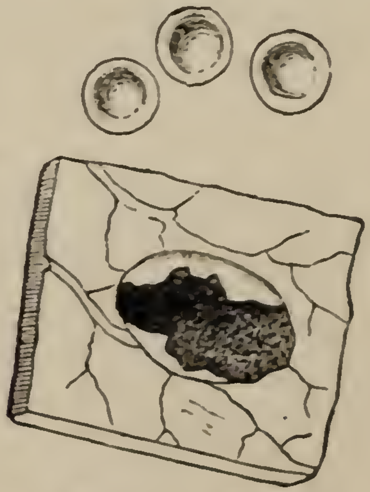

Fig. 17. *Uredo.*

preceded on the same plant, or even accompanied in the same pustule, by yellowish or brown undivided spores, which were formerly placed in separate genera, named *Uredo* if the spores were without stalks, or *Trichobasis* if short stalks were present,

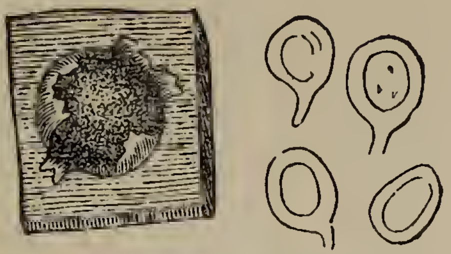

Fig 18. *Trichobasis.*

or *Uromyces* if the stalks were longer and permanent. These

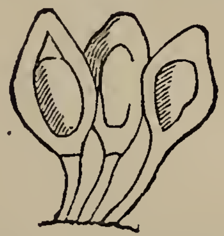

Fig. 19. *Uromyces.*

genera were included in the *Cæomacei*, which have undivided spores. The disease of wheat called bunt (*Tilletia caries*), and various grass smuts, also belong to this order. The spores of bunt are included within the grains of wheat, are of globular shape, and present under the microscope a reticulated appearance. The *Æcidiacei*, *Cæomacei* and *Pucciniæi* are however purely artificial divisions, the fungi belonging to them representing only different stages of development of the same plants, and the three groups will doubtless ultimately be merged into one when our knowledge of the different members of these groups is more complete than at present.

HYPHOMYCETES (THREAD FUNGI).

This division includes a number of moulds and mildews, some of which are doubtless only stages in the development of other fungi, or asexual forms of them, and not distinct species.

The genus *Peronospora* is one of the most important of this order, its members being most active agents in effecting the destruction of vegetables. The threads or *mycelium* penetrate the tissues of plants, and send out through the breathing pores of the leaves erect branched threads bearing at the apices deciduous spores (*conidia*), which fall off and propagate the mycelium. The mould is preserved during the winter by means of oospores or resting spores—*i.e.*, spores with a thicker coat, so as to resist atmospheric influences—formed inside the tissue of the plant. *P. infestans* is the cause of potato disease. *P. nivea* produces the fungoid disease of parsnips. *P. ganglioniformis* attacks lettuces. *P. Viciæ* destroys peas, and *P. Schleideniana* is very destructive to onions, preventing the plants from coming to maturity. These are mostly distinguished by the shape or colour of the spores (*conidia*). *Aspergillus glaucus*, formerly placed in this division, is a common mould occurring on bread, cheese, etc.

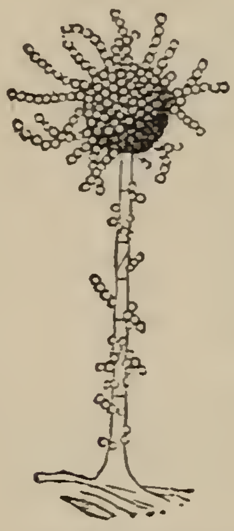

Fig. 20. *Aspergillus glaucus.*

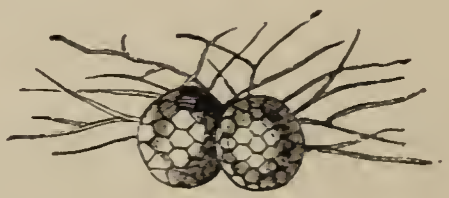

Fig. 21.
Eurotium herbariorum.

The jointed threads are crowned with a globose head, covered with necklaces of spores. This plant has been proved, however, to be the conidia-bearing stage of *Eurotium herbariorum*, a fungus which belongs to the *Ascomycetes*

PHYSOMYCETES (Capsule-bearing Moulds).

This division differs from the last chiefly in the fact that the spores are contained in well-defined spore-cases. It contains but few species worthy of special notice.

Ascophora Mucedo is common on bread, is of an ashy grey colour, and has terminal globose or oval spore-cases.

Mucor Phycomyces is a yellowish or olive-coloured mould growing on fat or greasy matter, and *Mucor Mucedo* is a blackish mould growing on preserves, paste, or fruit. *Zasmidium cellare* is the curious blackish, cobweb-like fungus that runs over bottles of wine in vaults and cellars.

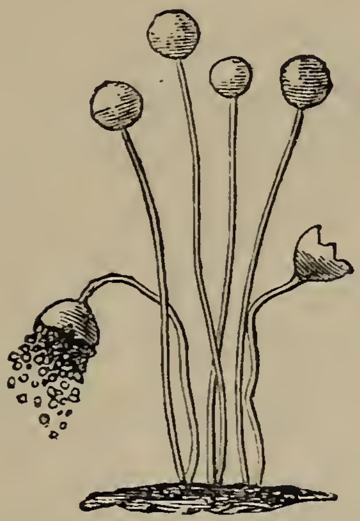

Fig. 22. *Mucor mucedo.*

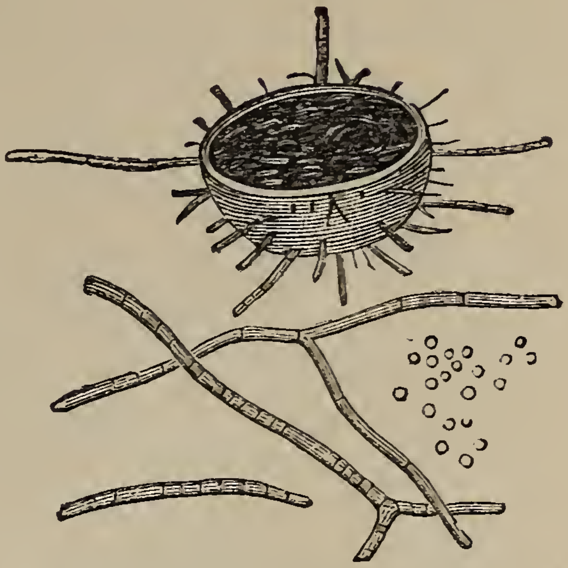

Fig. 23. *Zasmidium cellare.*

ASCOMYCETES.

This division contains several very well marked groups.

The *Perisporiacei* are mostly found on the under side of leaves in the autumn. The threads or *mycelium* are barely discernible by the naked eye, but with a lens they may be seen as delicate white threads accompanied with scattered black dots; these dots, often scarcely so large as the head of a small pin, are in many species beautiful microscopic objects, being surrounded with delicate, variously branched filaments. They may usually be found in September and October. Those found on the leaves

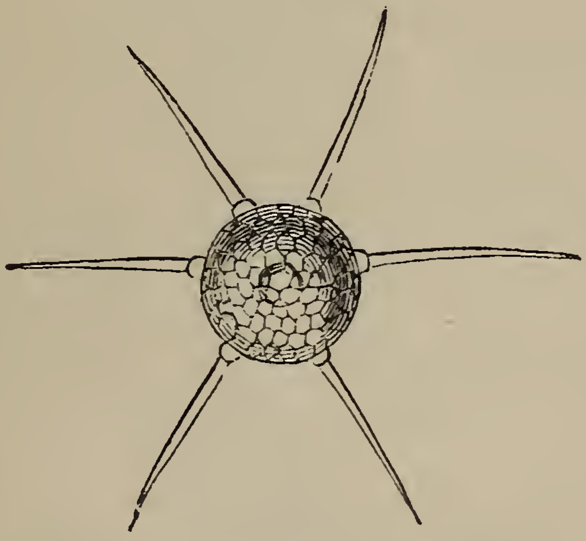

Fig. 24. *Phyllactinia guttata.*

of the hazel, *Phyllactinia guttata*, of the willow, *Uncinula adunca*, of the maple, *Uncinula bicornis*, and on the plum leaf,

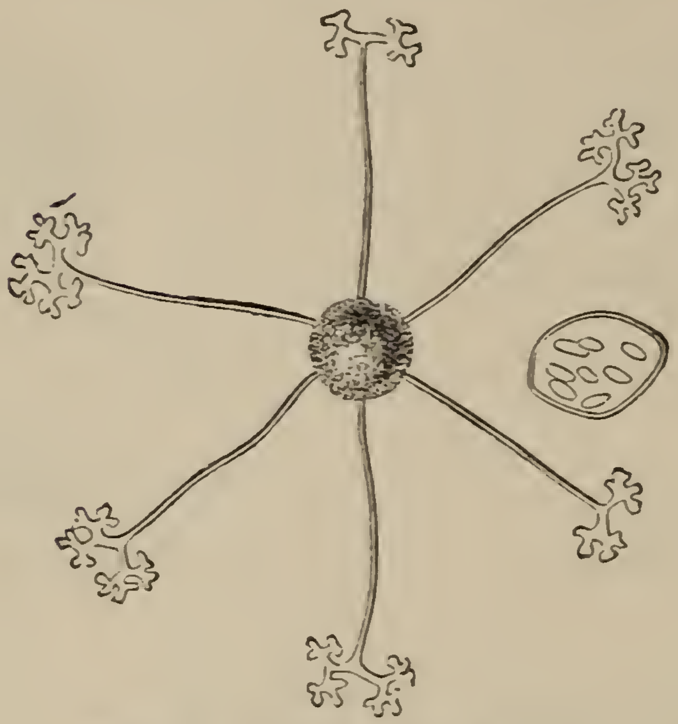

Fig. 25. *Podosphæria Kunzei.*

Podosphæria Kunzei, are all pretty objects; as is also the *Ascotricha chartarum*, or paper mildew. *Sphærotheca Castagnei* is the hop blight, *S. pannosa*, the rose blight, *Microsphæria Grossulariæ*, the gooseberry blight.

The *Helvellacei* are widely different in their character and appearance, having in some cases a fleshy stalk and a cap like that of an unexpanded mushroom. Of these, the common morel, *Morchella esculenta*, may be taken as one of the types. It may be found occasionally in woods in May. The cap-like portion has no gills, but has deep pits or cavities in its substance, which are lined with the *asci* or bags containing spores. Another type is found in the beautiful scarlet cup-shaped fungus, about the size of a sixpence, which is often met with on decaying sticks about Christmas time. In this plant the stem is very short, and the *asci* or spore-cases cover the whole inner surface of the cup.

Another beautiful species of this genus is the *Peziza aurantia*, which grows in clusters on damp ground in September and October. The orange cups of this species are often one to two inches in diameter, and somewhat irregular in shape. Several of the species of *Peziza* grow on dung, forming small red discs, others on dead branches of trees.

Helotium æruginosum, a species of a deep green colour, is rather rare locally, but is not unfrequently found on dead oak branches, which are coloured bright green with the mycelium or threads of the fungus. The wood thus coloured is used in the manufacture of the celebrated Tonbridge ware.

The *Tuberacei* are remarkable for living underground. Of these the truffle, *Tuber melanosporum*, may be taken as the type. They are mostly found in October in woods of beech or oak, and prefer a calcareous or sandy soil. In this plant the *asci* line irregular cavities in the interior of the fungus. *Tuber æstivum*, the common English truffle, is found chiefly under beech ; *T. macrosporum*, which has a garlic odour, under oaks ; and *T. brumale*, which is found from October to January, under oaks and white poplar. Truffles are usually found in oak woods after the trees have been planted about ten or twelve years, and continue to appear from ten to fifteen years. As much as 60,000 lbs. of French truffles are stated to be annually obtained in the department of Vaucluse alone. The fungi of this group may often be detected by raking away the dead leaves and carefully looking for a mycelium on the surface of the soil. This, however, disappears when the truffles are mature.

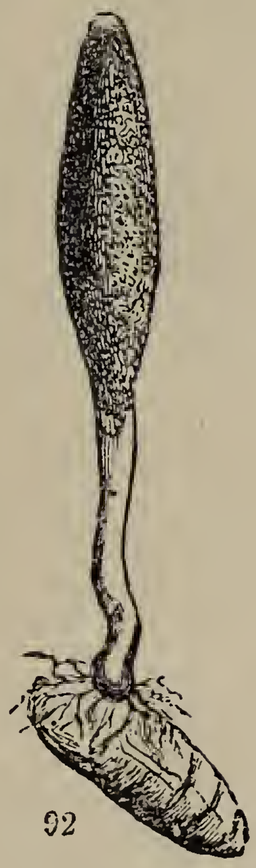

Fig. 26. *Torrubia militaris.*

The *Sphæriacei* is a very large group, the majority of which occur on dead sticks, etc., and present the appearance of small raised dots, usually of a black or red colour, more or less crowded together. These dots consist of a case or peridium, opening by a pore, and containing spores enclosed in asci. In a few cases these are borne on a distinct stem, of which they occupy the upper portion, and the plant bearing conidia or asexual spores is often very different in form.

There is a very singular plant belonging to this family, *Torrubia militaris*, found occasionally in damp woods in autumn, which consists of a red fleshy cylindrical stem one or two inches high, the upper portion being covered with red dots or *perithecia*, containing asci. On digging it up it will be found to grow on the dead chrysalis of a moth. The plant bearing conidia is slender, white, mealy, and slightly branched, and was formerly known as *Isaria farinosa*.

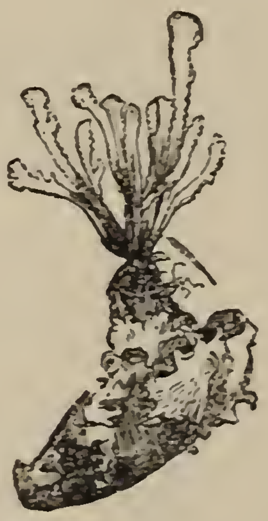

Fig. 27. *Isaria farinosa.*

A very common fungus belonging to this family is the *Xylaria Hypoxylon*, of which the plant bearing conidia, frequent on old stumps, is known as the candle-snuff fungus. It is black, cylindrical, or compressed, about one to two inches high, and whitish or mealy upwards. The form bearing asci (fig. 29) is entirely black.

The roundish, woody, black knobs, looking like charred wood, often found on decaying ash trees, and showing concentric zones when broken, belong to another member of the *Sphæriacei*, which is called *Hypoxylon concentricum*. When mature, and placed on white paper, the black spores will be ejected to a considerable distance on the paper around it.

Ergot of rye, which transforms the grain of rye into a hard blackish body, consists of the hard spawn or mycelium of a fungus belonging to this family, and which remains in an inactive state during the winter. This hard mycelium (*sclerotium*)

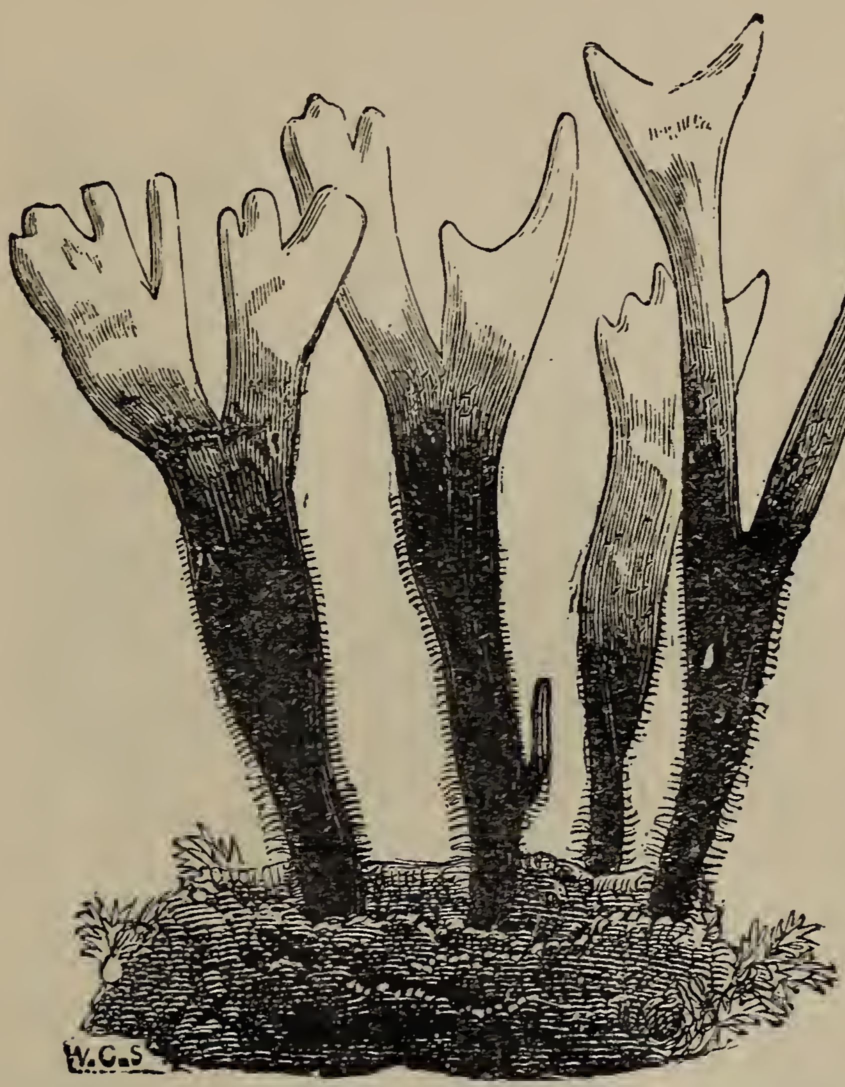

Fig. 28. *Xylaria hypoxylon,* form bearing conidia

when placed on damp sand in April gives rise to a little fungus, *Claviceps purpurea,* about a quarter of an inch high, in shape like a miniature mushroom, but with a solid cap, and containing spores enclosed in asci. The conidia-bearing form was formerly named *Oidium abortifaciens*, and the form bearing *stylospores* is supposed to be *Fusarium heterosporum,* both of which were formerly placed in the *Hyphomycetes.*

The pretty little red dots found on dead currant twigs and other sticks is a species of *Nectria,* of which the compound dots are the sexual form bearing asci, and those which are simple are the conidia-bearing form. A dark green plant resembling a Clavaria, Geoglossum viride, and found growing amongst grass in the autumn, also belongs to the ascomycetes.

Those who can afford the luxury of a microscope will find ample amusement and instruction in the examination of the fungi of the *Ascomycetes*, as well as those of the *Hyphomycetes*, *Coniomycetes*, and *Physomycetes*. The *Hymenomycetes*, although apparently the easiest fungi to deal with, on account of their size, are very difficult to discriminate, many of the species differing in details which only a practised eye can detect. They are, moreover, difficult to preserve, so as to present anything

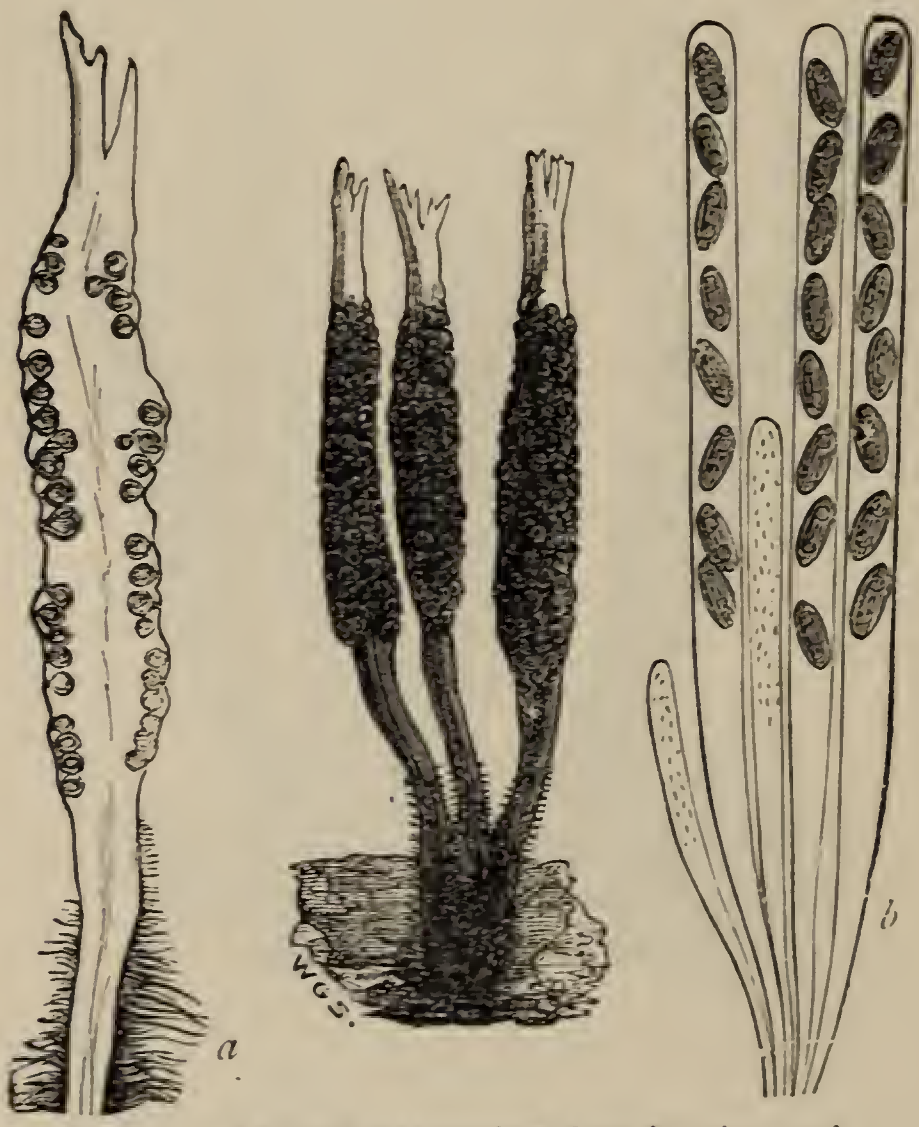

Fig 29. *Xylaria hypoxylon*, form-bearing asci.

a. Vertical section showing peridia. *b.* asci and spores.

like their natural appearance. An excellent series of figures of the Agarics is now being published by Dr. M. C. Cooke (2, Grosvenor Villas, Junction Road, Upper Holloway), which will be found invaluable in identifying the species of this family.

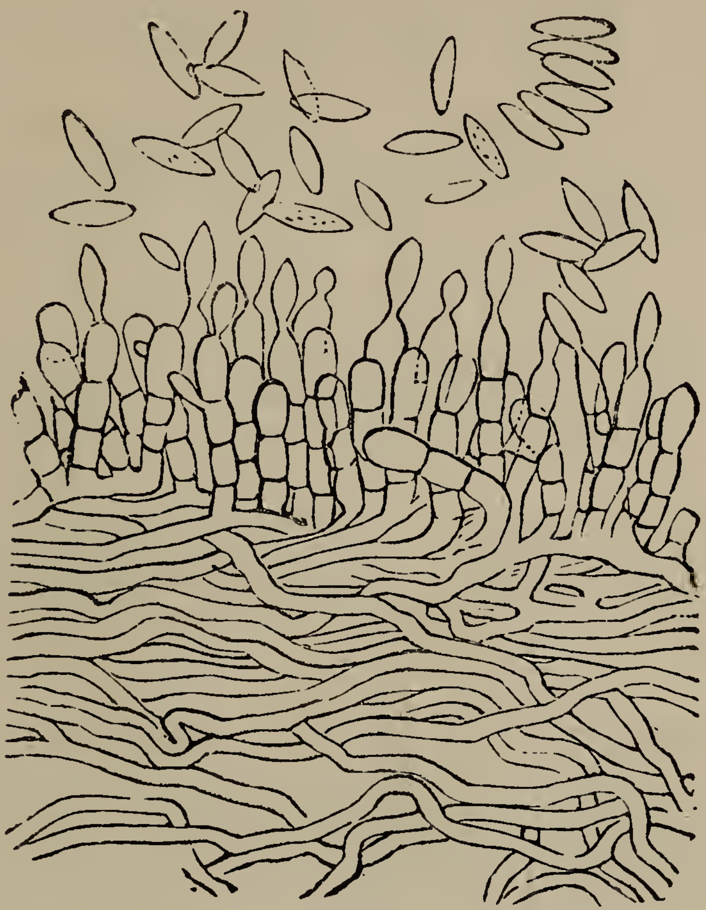

Fig. 30. *Oidium abortifaciens.*

Mr. English, of Epping, has lately published a book, which describes a mode of preserving fungi so as to retain their natural colour and habit as much as possible.

TABULAR ARRANGEMENT OF FAMILIES AND ORDERS, ETC.

DIVISION I. SPORIFERA. SPORES FREE OR EXPOSED.

I. *Spore-bearing surface, naked when mature.*

a. Spore-bearing membrane on under surface of cap—HYMENOMYCETES

Spores spread over gills—*Agaricini.*
,, ,, over tubes or pores—*Polyporei.*
,, ,, over prickles—*Hydnei.*
,, ,, over an even or wrinkled surface—*Auricularini.*

b. Spore-bearing membrane on upper surface, or encircling.

Plants club-shaped, branched—*Clavariei.*
,, lobed, or convolute, gelatinous—*Tremellini.*

II. *Spore-bearing surface inclosed, set free only by rupture*—GASTEROMYCETES.

a. Spores forming small proportion of the plant; plants subterranean—*Hypogæi.*

Spore-bearing surface slimy, or becoming soft—*Phalloidei.*

Spores agglutinated into nearly spherical bodies, inclosed in plants more or less cup-shaped—*Nidulariacei.*

b. Spores forming a dusty mass when ripe, occupying a large proportion of the plant, inclosed in a membranous envelope; stalked; spore-bearing surface convolute—*Podaxinei.*

Cellular at first, drying up into a dusty mass of threads and spores—*Trichogastres.*

Gelatinous at first, outer coat containing at length a mass of dusty spores and threads—*Myxogastres.*

III. *Spores on inconspicuous threads*—CONIOMYCETES.

a. Growing on dead or dying plants.

1. Bursting through the epidermis; perithecium (special cavity) more or less distinct—*Sphæronemei.*

Perithecium obsolete or absent—*Melanconei.*

2. Superficial. Spores compound or dividing—*Torulacei.*

b. Growing on living plants.
  Spores inclosed in a special cavity—*Œcidiacei.*
  Spores not inclosed in a special cavity. Spores subglobose, simple—*Cæomacei.*
  Spores mostly oblong, divided—*Pucciniæi.*

IV. *Threads conspicuous, bearing naked spores*—HYPHOMYCETES.
a. Threads compacted into a stem.
  Spores dry—*Isariacei.*
  Spores forming a moist mass—*Stilbacei.*
b. Threads free, or uniting at intervals.
  Fertile threads dark. Spores mostly compound—*Dematiei.*
  Fertile threads not dark, distinct from mycelium. Spores mostly simple—*Mucedines.*
  Fertile threads not dark, scarcely distinct—*Sepedoniei.*

DIVISION II. SPORIDIA INCLOSED IN ASCI.
V. *Spore-cases distinct, on threads*—PHYSOMYCETES.
  Threads felted, beaded like the antennæ of insects—*Antennariæi.*
  Threads free, spore-cases terminal or lateral—*Mucorini.*
  Aquatic—*Saprolegniei.*

VI. *Spore-cases formed from the cells of a membrane* (hymenium)—ASCOMYCETES.
a. Asci often evanescent.
  Receptacle club-shaped, asci springing from threads—*Onygenei.*
  Receptacle free, asci springing from its base—*Perisporiacæi.*
b. Asci persistent.
  Receptacle opening by a pore—*Sphæriacei.*
  Receptacle hard, splitting open at maturity—*Phacidiacei.*
  Subterranean—*Tuberacei.*
  Fleshy, or waxy, or gelatinous; asci superficial—*Elvellacei.*

BOOKS ON FUNGI.

The following may be recommended as more fully treating of Fungi :—

1. Fungi : their Nature, Influence, and Uses. By M. C. Cooke and the Rev. M. J. Berkeley.
2. Microscopic Fungi. By M. C. Cooke.
3. Outlines of British Fungology. By the Rev. M. J. Berkeley.
4. Handbook of British Fungi. By M. C. Cooke.
5. Popular British Fungi. By J. Britten.
6. Badham's Esculent Funguses. 2nd Edition. F. Currey.

The first two of these, being of an explanatory character, will be found most useful to the beginner ; No. 4 is valuable for giving descriptions of the species, and No. 5 deals largely with the folk lore of fungi. The "Outlines of British Fungology" contains a large number of useful illustrations.

LICHENS.

BY

PETER GRAY.

HANDBOOK OF LICHENS.

LICHENS are perennial cellular plants, varying exceedingly in form, and usually growing in patches, more or less regular in outline, upon the surface of rocks, on the earth, the bark and leaves of trees, on decayed wood, on mosses, and sometimes on other lichens. Internally they are mainly composed of branched and interlacing threads, consisting of very narrow cells, forming what is known technically as false tissue, and which is structurally the same as the substance of fungi. Essentially, also, their fructification is identical with that of the ascomycetous fungi (Peziza, Sphæria, etc.). Fries says that lichens have the vegetation of algals and the fruit of fungals. Agardh, another eminent authority, considers them more nearly allied to fungi. The texture of the vegetative portion of lichens, however, is always sufficient to distinguish them from the latter, and the lichen plant invariably includes little green bodies (gonidia) distributed throughout its substance, either in layers or beaded rows. Lichens, again, seldom, if ever, draw any portion of their nutriment from the substance on which they grow, living upon the surrounding atmosphere. They are, more than any other plants, impatient of impurities in the air, and their abundance in a fully developed and fruiting state is, says Leighton, a sure and certain indication of the purity of the atmosphere and the salubrity of the climate. They are light-loving plants too, but appear to shun the direct rays of the sun, preferring in temperate climates a northerly or north-western aspect, and under the fervid tropics sheltering themselves in shady places. They cannot live without moisture, but they are able, without losing their vitality, to endure long periods of drought, growing slowly and intermittingly. The lichen plant may be dried so as to be easily pulverised without injury; but when saturated with water it has in most genera a leathery consistence, and is tough, elastic, and flexible; in a few cases when in this condition it is slimy and gelatinous. When moisture falls upon the growing plant, it is rapidly absorbed by the entire surface, and the lichen then resumes its active functions. Thus lichens receive their greatest development in warm moist climates, like that of New Zealand.

It is probably in great measure owing to the long periods of rest they obtain in dry seasons that lichens are so long lived. They certainly attain a very great age. Berkeley, in a note to his "Introduction to Cryptogamic Botany," says: "Some of the large patches of Parmelia which grow on rocks are of very great age. Patches of such lichens as Lecidea geographica probably date from almost fabulous periods, and even small patches are often of considerable age. I have myself watched individuals for twenty-five years, which are now much in the same condition as they were when they first attracted my notice." This lengthened span depends also in some degree on the mode of growth in foliaceous species, like Parmelia, in which the centre first perishes, while the plant continues to extend by vigorous growth from all parts of the circumference.

Modern systematists place lichens, as a homogeneous class, in the order of Nature, between the fungi and the frondose liverworts; but recently certain eminent continental botanists have maintained that the lichen is a composite plant, consisting of a fungus (the hyphæ) parasitic on an alga (the gonidia), which will be referred to more fully further on. This theory is vigorously opposed by most lichenologists.

Of all plants, lichens, as an object of study, have up to quite recent times been the most neglected. Before the time of Tournefort, who flourished towards the end of the seventeenth century, they were mixed up indiscriminately among the mosses, hepatics, and seaweeds; and Linnæus was content to arrange them under the single genus Lichen in his class Algæ. Lichens, however, well deserve the attention of the student of nature, not only because of the interesting points of structure they present, but on account of their many economic uses. The herds of reindeer which constitute the wealth of the wandering Lapp, are foddered in winter on one species of lichen, the reindeer moss (Cladonia rangiferina), for these animals will not touch hay; the "Iceland moss" (Cetraria Icelandica) employed in other countries as an easily assimilated food for invalids, enters largely into the ordinary sustenance of the Icelander, and with it he also supplements the scanty grazing of his cattle and sheep, while in large districts of Asia and Africa, ground lichens are used to mix with bread flour. But the most important of their economic applications is found in the valuable dyes which many of their species yield. The plants so employed in this country are chiefly imported from the Scandinavian peninsula, from Africa, and from some of the Atlantic islands; but formerly several British species were largely used in dyeing, and their collection was a source of profitable employment to the peasantry of Wales and the Scottish Highlands. Formerly many species were employed as medicaments; Cetraria Icelandica alone maintains its place in the English Pharmacopœia. In the economy of nature, lichens hold an important place as the pioneers and basis of all vegetation. Several thousand species are

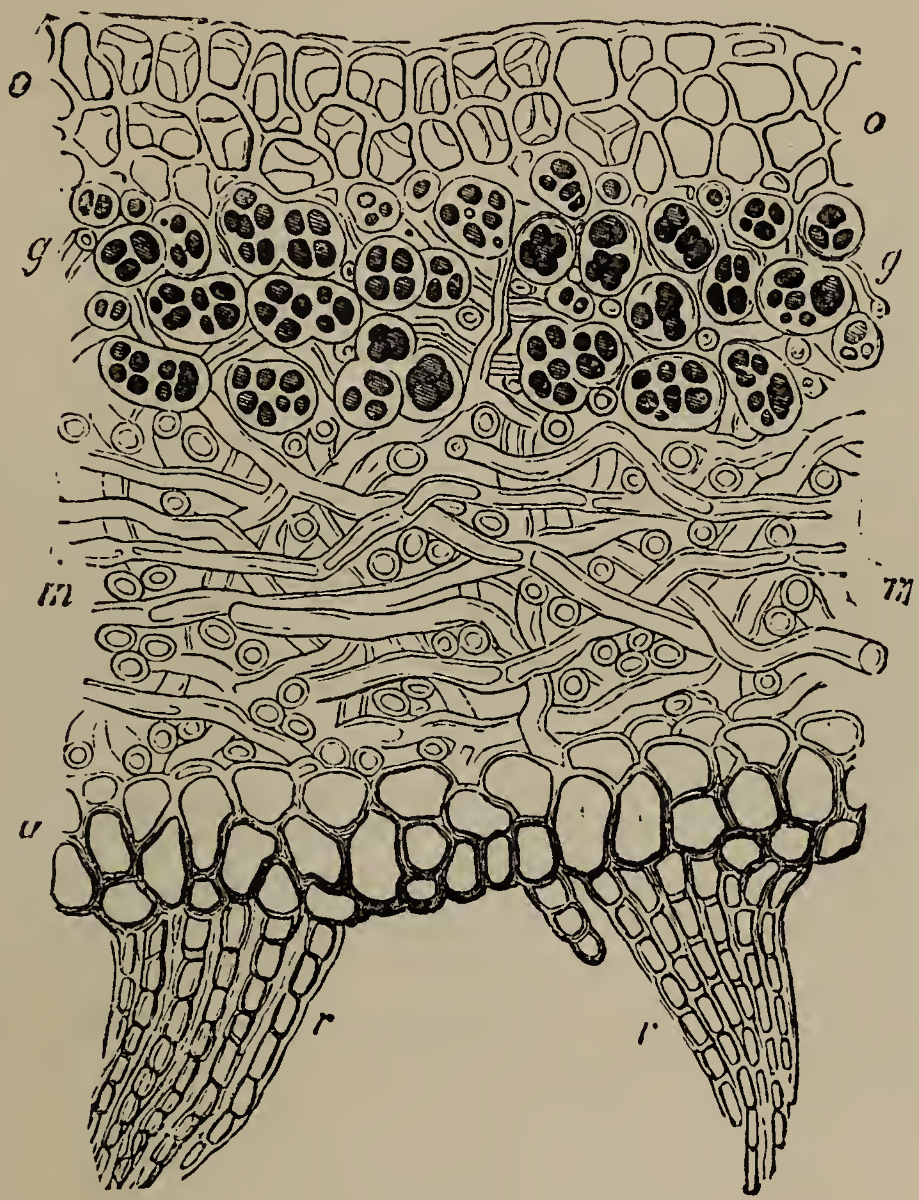

Fig. 1.—Transverse section of the thallus of Sticta fuliginosa, magnified 550 diameters. *o*, limitary cells of upper side; *u*, of under side, with rhizoids, *v*; *m*, hyphæ theads of interior of thallus; *g*, green gonidia.

enumerated in botanical text-books, but it is difficult to reckon them exactly, owing to their great liability to variation, and the different views of systematists as to what constitutes specific difference, a difficulty experienced with lichens more than with any other kind of plants, except, perhaps, fungi. The prevailing estimates are probably considerably under the mark.

The vegetative system of lichens is termed the thallus. (Fig. 1.) The forms it assumes are very various. They may, however, be arranged under two grand divisions—the horizontal, which is the typical form, and the vertical or fruticulose. The former may be subdivided into the crustaceous and the foliaceous or frondose. The crustaceous thallus is sometimes thick, dense, and hard, when it is termed tartareous; many or most of the lichens of this description furnish the pigments used by the dyer. They adhere closely to their matrix by the whole under surface, and are believed by some naturalists to corrode the rocks on which they usually grow, and in that way help to form a vegetative soil for the higher classes of plants. When the crustaceous thallus is very thin it is termed leprose, and there is also a kind of crustaceous thallus so much disintegrated as to deserve the appellation of pulverulent. This, however, is now ascertained to be merely a rudimentary, or an abortive form of lichen, in the latter case produced by the absence of the necessary conditions of normal development. Such forms at one time were considered distinct species, described under the generic names of Lepra, Lepraria or Variolaria. Certain descriptive terms are applied to the outline of the thallus, which, like other technical terms, in the arts as well as in the sciences, are employed in text-books for the sake of accuracy and brevity, are essential for the attainment of these important ends, and are therefore necessary to be learnt by the student. When the crustaceous thallus has no visible limits or border, it is called effuse; uniform, when it has a definite shape and distinct margin. When its circumference is radiate or stellate, it is effigurate; when its outward segments are leafy, squamulose; and imbricate when these segments (laciniæ) are arranged over each other, like the tiles of a house. In the foliaceous lichens the thallus is a flattened, leaf-like expansion, in texture membranaceous, coriaceous (horny) or cartilaginous, and its margin divided into segments, which, when they are large and broad, are denominated lobes, and when narrow, laciniæ. This structure characterizes the largest and most brilliantly coloured lichens, which mostly grow on trees, or on the ground, rarely on rocks. Many of them adhere to their bases of support by means of minute fibres, proceeding from the under surface of the frond ; in a lesser number there is only a single point of adhesion, by means of a disc.

The vertical lichen thallus is mostly of two kinds, fruticulose, that is shrubby, and filamentous or thread-like. Fruticulose lichens, of which the "reindeer moss" is a typical example, are composed of a shrub-like aggregation of rigid, erect, simple or branched stems, sometimes springing from a common disc-like

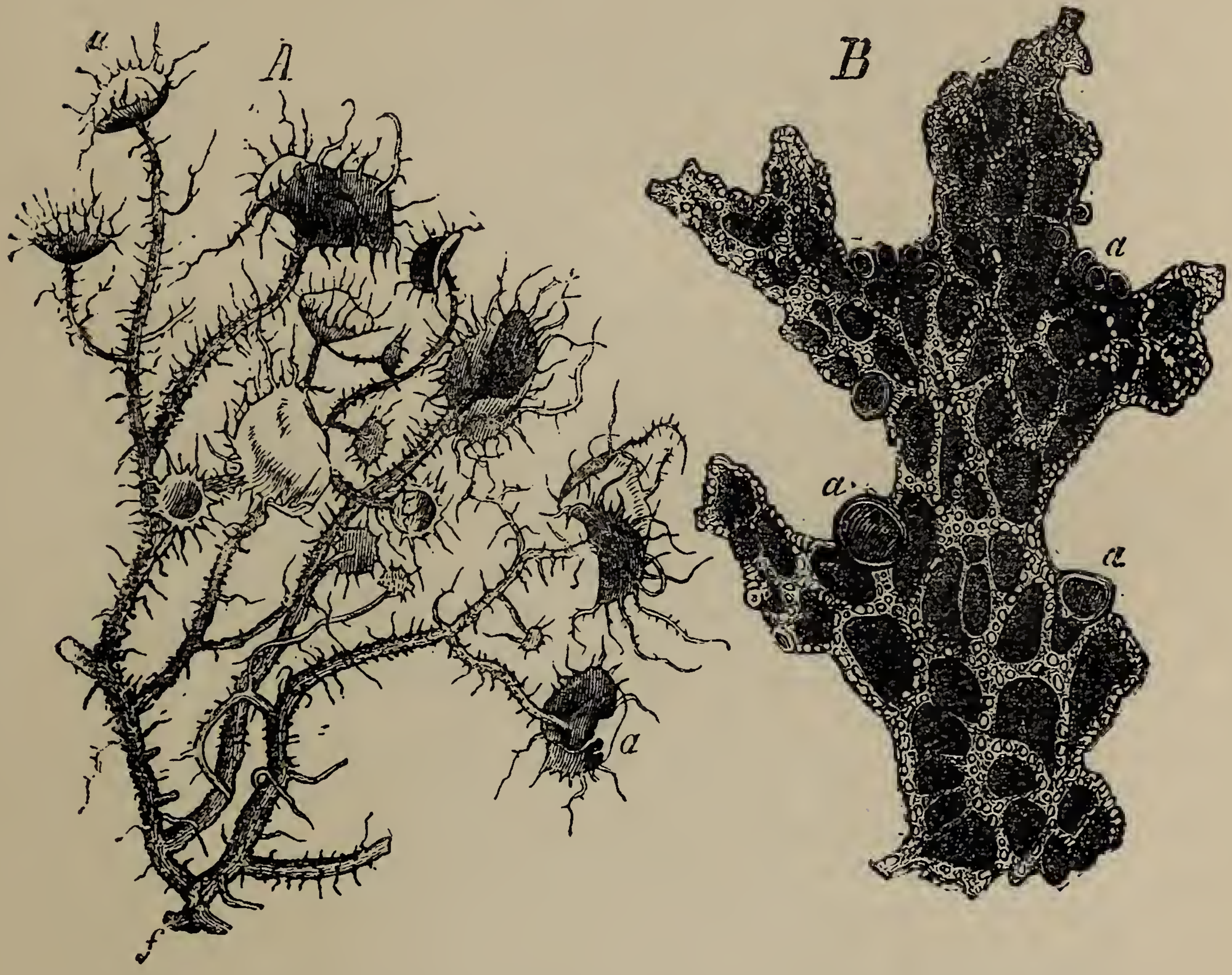

Fig. 2.—*A*, Usnea barbata, a fruticulose lichen, natural size. *a*, apothecia ; *f*, disc by which it is attached to the bark of a tree. *B*, Sticta pulmonacea, a foliaceous lichen, underside. *a*, apothecia.

base, and sometimes from a small foliaceous or crustaceous thallus. The filamentous species consist of a mass of thread-like segments of which a good example is to be found in Usnea, that so often hangs in thick masses from the branches of old fir trees. (Fig. 2.)

In colour the lichen thallus is generally some tint of green, grey, brown, yellow or black, but occasionally white, the colour being confined to the outer layer. Much of this variety of colour depends upon the amount of exposure to light and to atmospheric changes; in several cases it is suspected to arise from the absorption by the plant of some chemical constituent of the substance on which it grows. In the majority of lichens, moistening with water, by increasing the transparency of the outer layer of the thallus, allows the colour of the gonidia which are dispersed through its substance to shine through, and thus to impart a greenish tint to the paler hued species.

Lichens are developed from what is termed a hypothallus, which is a rudimentary aggregation of delicate tubes growing from the spore or other vegetative centre, resembling and probably of the same nature as the mycelium or "spawn" of fungi, branching and interlacing until they constitute a loose, felted mass, and giving birth to the fibres in some cases, to the spongy substance in others, by which the lichen is attached to the substance on which it grows. The hypothallus itself generally disappears ultimately, but in some lichens, as in Lecidea geographica, it is persistent, forming in that species a black, radiating fringe, surrounding the yellowish-green thallus. As the development of the lichen proceeds, there first appears, superimposed upon the hypothallus, a layer of minute, colourless cells, closely adhering to each other and to the hypothallus. This constitutes the skin or bark of the under surface of the lichen. Upon this stratum is gradually deposited a thin layer of bright green cells, the gonidia, considered by the supporters of the composite theory as algæ of a low type, upon which, they maintain, the colourless or fungoid element of the plant is parasitic. While the external tissue of both surfaces consists of closely aggregated cells, spherical in form, unless where altered by pressure or abortion, the cells of the gonidic layer are loosely aggregated, both as regards the other tissues of the plant and one another. They are filled more or less with bright green chlorophyll, the substance which gives the prevailing green hue to all vegetation. Above this gonidic stratum lies another, occupying the centre of the thallus, white and cottony, and more or less thick,—the medullary layer. This is a loose network of branching tubes, empty or containing a transparent gummy matter, the interstices of the network being filled with air. These tubes, however, are in no wise analogous to the vessels in the higher forms of plants; but they imbibe water into their interstices with great readiness and rapidity. In some species the gonidia, instead of being regularly disposed in layers, are distributed throughout this medullary substance. Above the medullary layer in the typical lichen there is another stratum of gonidia, upon which is superimposed a tough membranaceous or coriaceous layer, identical with that protecting the under surface, and out of which spring the sexually reproductive organs of the plant. In some abnormal conditions, already referred to, and depending, probably, on peculiar states of the atmosphere, or on the absence of light, the hypothallus alone is developed, or the whole plant is broken up into a powdery mass. An excessive development of the gonidial element is frequently the cause of this latter modification, these organs bursting through the cortical layer of plant, and appearing on the surface in numerous clusters (soredia). Sachs, a distinguished supporter of the composite theory, first propounded by Schwendener, holds that the mode of growth, branching, and external structure of the lichen thallus may be determined either by the gonidia or the hyphæ, each in either case taking only a secondary part in the formation of tissue, although he admits that the former case is that of very few lichens. Bornet goes farther, and describes the manner in which the hyphæ attach themselves to the algal cells, and even penetrate into them and absorb their contents; while Schwendener himself professes to have identified nine groups of algæ, as the hosts of one or another fungus, each together constituting a lichen. On the other hand, it is more generally admitted that many unicellular plants, usually placed among the algæ, are simply lichen gonidia in various stages of development.

Lichens are reproduced by spores which are developed in thecæ, these again generated in organs (apothecia) which normally consist of two parts, the thalamium, or receptacle, and the exciple, its envelope. The apothecia are frequently very conspicuous objects, mostly appearing as small shields on the surface of the thallus, often brightly coloured, and of a different colour from the thallus. The structure of the thalamium was formerly employed to divide lichens into two main groups, according as it is open (gymnocarpous), or angiocarpous, that is, forming a globular body, opening, when mature, by a minute pore (ostiole). The exciple is an envelope enclosing and protecting the apothecium, sometimes forming merely a margin or border to the thalamium, at other times both base and border. It is, however, sometimes absent. When it is formed of an extension of the tissues of the thallus, it is termed thalline, and proper when it differs in structure and colour. Usually each exciple contains a single thalamium. The form and construction of the apothecium are still of great use in the identification of lichens, and the various kinds have received distinctive names. When it is round, flattened and platter-shaped, with an exciple formed of the substance of the thallus, which is best ascertained by section, it is said to be scutellate, and peltate when of a similar form but without a distinct exciple ; when round, convex, or semi-globular, with a non-thalline exciple, it is called patellate ; in those cases where it is rounded and seated on a stem-like support, it is capitulate. In the curious lichens in which the outline of the linear apothecia frequently simulate oriental written characters, it is termed lirellate ; and there are other modifications, each of which has its distinctive appellation. The outer covering of the thalamium is often, as has been already indicated, of a different colour from the thallus, presenting various shades or combinations of brown, black, red, or yellow. These colours, as in the well-known scarlet-fruited "cup-moss," are often very vivid and beautiful.

In its internal structure the thalamium is built up of a series of closely aggregated cellular tubes, arranged vertically to its surface, which rise from a tissue, the hypothecium, formed of minute spherical cells. The most important of these tubes are the thecæ, the cases in which the spores are ultimately developed. They vary somewhat in outline in different species, but the lower end always contracts abruptly into a narrow footstalk. The wall of the theca, which is somewhat thick, especially in the young state, is lined towards the apex by a delicate membrane, the spore-sac. The contents of the spore-sac, which are at first fluid or somewhat granular, gradually develop into spores, the normal number of which in each theca is eight, although sometimes only one or two, whilst in some angiocarpous genera they amount to hundreds. When mature, the spores in the gymnocarpi escape through the ruptured summit of the theca, and that organ disappears ; in the angiocarpous species they are ejected through a terminal ostiole or pore ; although during the life of the hypothecium, which, like the thallus, is perennial, a constant succession of thecæ is developed. Surrounding the thecæ, resembling them in form, and constituting the bulk of the thalamium, are the paraphyses, which are composed of six or eight cylindrical cells, are larger than the thecæ, and filled in their lower part with a transparent fluid, the upper cells, however, being coloured. They have generally been regarded as rudimentary, sterile, or abortive thecæ. The apothecium mostly originates in the medullary tissue of the thallus ; in certain gelatinous lichens it arises immediately beneath its surface. In the typical lichens, according to Sachs, it appears in its commencement as a very small roundish ball of confused, interwoven hyphæ, on the outer side of which a tuft of very delicate hyphæ, the first paraphyses, rises at a very early period. The further growth of the rudimentary thalamium takes place by the formation of new fibres and the growth of new paraphyses, the first asci eventually making their appearance in the centre of the thalamium. The growing apothecium then bulges more and more, and finally breaks through the layer of thallus which covers it; and the thalamium and margin of the exciple protrude, or the surrounding portion of the thallus rises and grows with it, forming a bowl-like rim. The mode of fertilization of lichens is still obscure. Certain small capsules sunk in the surface of the thallus, and opening by very delicate pores, when mature, emit minute needle-shaped or linear bodies, which are generally believed to be the fecundating element, and the analogues of the antherozoids in algæ, mosses, etc. Unlike these, however, they are destitute of cilia or other appendages. They are developed earlier than the apothecia, and on the outside of the parent cells, accumulating in great numbers in the cavities of spermagonia, whence they escape through an apical pore. If the observations of Stahl are to be accepted as accurate, the fertilization of lichens takes place before the development of the spore case, which is itself the product of a carpogonium fertilized by the spermatia. The carpogonium or unfertilized theca of Collema microphyllum is, he says, a hyphal filament, which forms closely appressed cells at some distance below the surface of the thallus, and is then prolonged straight to the surface, beyond which it projects. Spermatia, derived from the spermagonia, are disseminated over the surface of the thallus by the agency of moisture, and are thus brought into contact with the projecting cell of the carpogonium, to which they adhere. Their contents then find admittance, in consequence of the absorption of the cell wall, and thus fertilization takes place; the cells of the ascogonium, as well as those of the adjoining hyphæ, are thereby stimulated to growth, and the result is the formation of an apothecium, the asci being produced from the ascogonium and the paraphyses and the wall of the thecæ from the adjacent hyphæ. The formation of the apothecium thus exclusively from the hyphæ, or, as it is put, the "fungal constituent" of the lichen, is taken by the supporters of Schwendener's hypothesis as a proof that the lichen thallus is a fungal growth which is nourished as a parasite by an alga. The spores, when mature, are set at liberty by moisture penetrating the apothecium, when they are expelled, together with the fluid in the theca, the apex of which is ruptured, probably by lateral pressure from the swollen paraphyses. In the gymnocarpi they find their way to the surface of the thalamium, whence they are removed by the wind or rain. In the lichens which have a closed thalamium they escape by a terminal pore, and are found adhering in pulverulent masses to the surface of that organ.

The spores vary much in size, form, and colour. In form they are usually ovoid or ellipsoid, and very commonly consist of small cellules separated by distinct intervals or septa. When single-celled they are generally simple in shape ; when compound, often greatly irregular in outline. In size they are in a few cases large enough to be visible to the naked eye, more commonly they are so small as to be only distinguishable under high powers of the microscope. They are almost colourless in a young state ; when mature they assume various tints, mostly yellowish. The spore wall typically consists of two membranes, although sometimes one is absent—mostly the outer. Internally the spore consists of mucous or granular matter, in some species it is densely filled with oil globules. Germination takes place by the inner membrane of each spore cell putting out a thread, which ramifies and extends over the damp surface on which it is placed, and the ramification and intertwining of these filaments result in the formation of the hypothallus or mycelium, upon which, as we have seen, the new plant is developed.

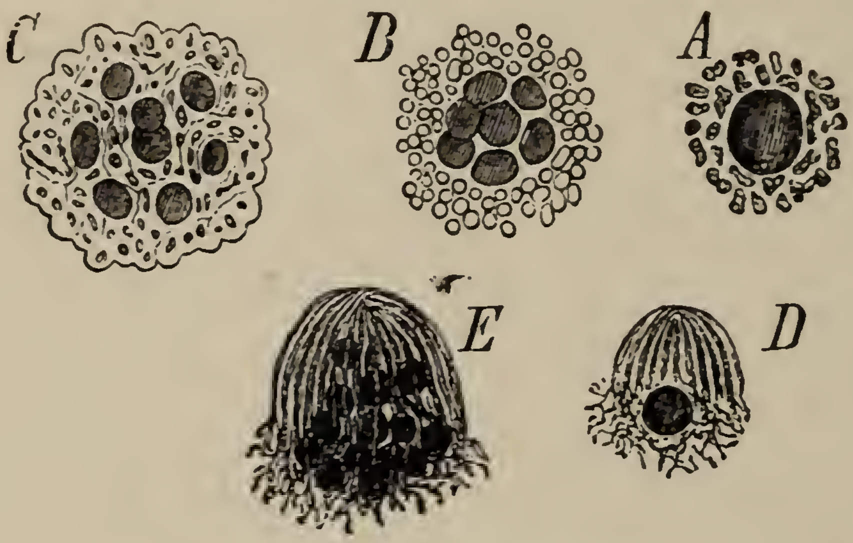

Fig. 3.—Soredia of Usnea barbata, magnified 500 diameters. *A*, soredium consisting of one gonidium covered with hyphæ. *B*, many gonidia formed by division. *C*, the gonidia separated by hyphæ. *D*, *E*, germinating soredia, growing apex formed of hyphæ, developing into a new lichen plant. (After Schwendener.)

Besides in this way by spores, most lichens are extensively propagated by soredia, organs analogous to the gemmæ of mosses, and perhaps to the bulbs produced in some of the higher orders of plants. (Fig. 3.) They are composed of tufts of hyphæ, each enclosing a single gonidium or group of gonidia, and each able to produce a new lichen thallus. In non-gelatinous lichens they are pushed out upon the thallus, often so abundantly as to form conspicuous white or coloured masses. In one genus they appear in the form of cup or urn-shaped bodies, and frequently the apothecia are rendered abortive by their substance breaking up into soredia. In certain crustaceous thalli they are aggregated into cone-like bodies. Species in these conditions were formerly considered as belonging to genera now suppressed, as Variolaria, Isidium, etc. In the gelatinous species the soredia appear as the gonidial layer. The process of soredial development in that division is thus described by Sachs. Single gonidia, or sometimes several together, become woven over by branches of hyphæ, which cling closely to them, and form an envelope of fibres; the gonidia divide repeatedly, and each daughter cell is again woven over; and this process is often repeated. The soredia accumulate in great numbers in the gonidial layer, and finally rupture the cortex. He adds, that, after escaping, the soredia can still further multiply outside the thallus, and, on the authority of Schwendener, that in one species this may occur while the soredia are still included in the parent thallus, soredial branches being thus produced. Some lichens also possess receptacles resembling spermagonia, and termed pycnidia, the nature of which has not been clearly ascertained. They contain bodies larger than spermatia, and more resembling spores.

As we have already seen, lichens are intimately related to fungi, and this is especially the case with such genera as Bæomyces; while on the other hand some genera bear a considerable external resemblance to algæ, as the gelatinous species, and particularly Lichina, at one time universally considered a seaweed, and afterwards bandied about between the two orders until at last it seems to have settled for good among the lichens, to which it undoubtedly belongs. Farther, such genera as Endocarpon, superficially viewed, would appear to offer a transition, by way of the Marchantiaceæ, to the higher classes. Differing and imperfect views of the nature and affinities of lichens for long prevented an approach to a natural classification, some systematists taking the fructification, others the thallus as the basis of their arrangement. That of Dr. W. Nylander, an eminent French lichenologist, is adopted by the

Rev. W. A. Leighton in his "Lichen Flora of Great Britain," the best manual for the student of British species. That would be a sufficient reason for following it here; but it is also preferable on its own merits, being, as the author of "Lichen Flora" says, "founded on a general consideration and balancing of all the parts of lichens, their external and internal structure." The arrangement of the genera in the "Lichen Flora" is as follows:—

FAMILY I., BYSSACEI. Plants of a finely filamentous nature, represented in Britain by one tribe, Sirosiphei, which includes two British genera, Sirosiphon and Gonionema, the species of which grow on rocks.

FAMILY II., COLLEMACEI. Thallus, gelatinous, filiform, and branched, or membranaceous and lobate.

Tribe 1, *Lichenei.* Thallus filiform, branched. Genera: Ephebe, Spilonema, Lichina, Pterygium, Leptogidium. A good many of the species contained in this and the following tribe were formerly included in the old genus Collema. Ephebe, which is not unfrequent in small cavities occasionally filled with water in rocks in the Highlands, is a plant of somewhat uncertain seat. At all events it has been claimed as an alga, but like Lichina, it has now taken an acknowledged place among the lichens. It consists of black filaments, and its apothecia are saucer-shaped. Lichina, with its two species or varieties, is common on all our rocky shores where the rocks are exposed at low water. It is about half an inch in height, and grows in dense patches, in colour and appearance exactly resembling a fucoid, although in fruit an angiocarpous and in texture a gelatinous lichen.

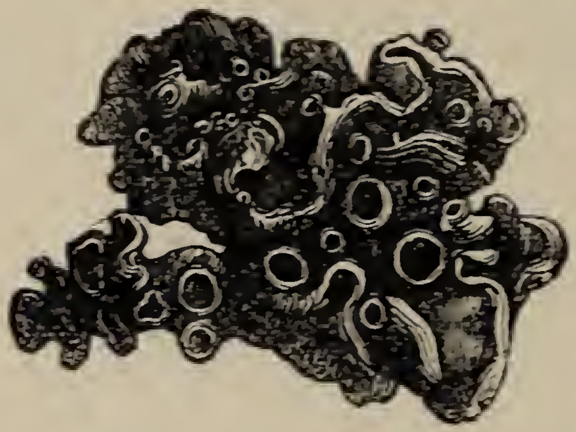

Fig. 4.—Collema pulposum, with apothecia.

Tribe 2, *Collemei.* Thallus membranaceous and lobate.

Genera: Synalissa, Pyrenopsis, Collema, Leptogium, Collemopsis, Pyrenidium. The restricted genus Collema, like the most of its allies, so closely resembles some of the algæ in texture, that it has often been considered identical with Nostoc, an undoubted alga. On the other hand, it may be observed that Nostoc has been frequently considered a lichen. But Nostoc consists of moniliform filaments embedded in a mucilaginous basis, while Collema developes tubes which ramify and become interlaced, as in the hypothallus of other lichens. (Fig. 4.)

FAMILY III., MYRIANGEACEI. Thalamium cellulose.

Tribe 1, *Myrangei.* Thallus black and powdery. Genus: Myriangium.

FAMILY IV., LICHENACEI. Thallus not gelatinous.

Tribe 1, *Calicei.* Thallus horizontally expanded. Genera: Sphinctrina, Calicium, Coniocybe, Trachylia. With this family we leave the alga-like lichens and enter upon those in which the fungoid character or aspect predominates. In the genus Calicium, within the old circumscription of which most of its modern tribal allies were included, the thallus is usually thin, often almost absent; but it is noticeable from its fruit, which resembles a small immature mushroom, the numerous capitula looking like little flat-headed pins stuck into the crust. The species of this tribe mostly occur on the rough bark of trees or on decayed wood in lowland forests. Sphinctrina turbinata and microcephala are parasitic on another lichen, Pertusaria.

Tribe 2, *Sphærophorei.* Thallus fruticulose. Genus Sphærophoron. In Sphærophoron the thallus is vertical and shrubby. S. coralloides, which is common on rocks in hilly districts, resembles a branch of delicate coral, and, as Berkeley truly remarks, constitutes, with its congeners, the great ornament of many a scattered boulder on the mountains. The thecæ in this genus are beautiful microscopic objects, the spores resembling rows of bluish black beads, supported on a long, narrow, tapering stalk.

Tribe 3, *Bæomycei.* Thallus horizontal, apothecium substipitate. Genera: Gomphillus and Bæomyces. Bæomyces and Gomphillus have the fruit, which resembles a small fungus, brightly coloured and elevated on a solid stalk, the thallus spreading as a tartareous crust over peaty or clayey ground.

Tribe 4, *Cladoniei.* Thallus foliaceous or podetiform, apothecia on footstalks (podetia). Genera: Cladonia, Pilophoron. The first is a somewhat extensive genus, and contains several interesting species. "The reindeer moss that whitens all the hill" of the poet, is the most important. It is very common all over Britain in suitable situations, chiefly alpine or subalpine, and the most widely distributed, perhaps, of all lichens In Lapland it is most abundant, and taller than in this country, frequently reaching a foot in height. The only pastures of the reindeer in winter are the barren tracts on which this plant grows ; and the Lapps frequently collect it like hay for winter fodder, and for their deer on a journey, four pounds a day being the quantity required by each animal on such occasions. When the ground is covered with snow, the deer clear it away with their horns to uncover the lichen. In some countries the reindeer moss is prepared for fodder by pouring hot water over it, then mixing it with cut straw and adding a sprinkling of salt. So prepared, it is greedily eaten by cattle, which under such a regimen are said to produce delicious butter, while their flesh becomes fat and sweet. The author of "Harmonies of Nature" speaks of a small breed of cows whose milk becomes wholly cream when fed on this lichen. Besides the reindeer, others of the cervine tribes feed upon it in winter. Reduced to powder and mixed with flour, it is also baked into bread, or it is boiled in milk or broth. The "cup-mosses" belong to the same genus. C. cornucopioides and C. bellidiflora, which bear their fruit in

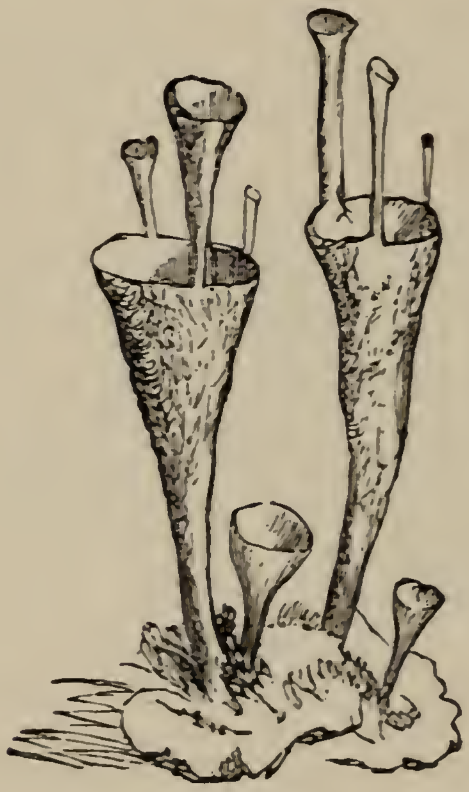

Fig. 5.—Species of Cladonia.

red tubercles as bright as red sealing-wax, and grow on heaths and hills, are common and well-known objects. The "cup-mosses" were formerly in much request as a demulcent in chest affections, and are still to be found in the herbalists' shops. (Fig. 5.)

Tribe 5, *Stereocaulei.* Genus: Stereocaulon. In fructification this genus approaches Lecidea, in its thallus it resembles the flowering plants. Forms of S. paschale are not unfrequent in which the plant simulates a small tree of the pine tribe laden with snow. It is widely distributed in both hemispheres. In Lapland it is often eaten by the reindeer when their accustomed food is not to be had; and game and other wild animals also feed upon it.

Tribe 6, *Roccellei.* Thallus branched, white; apothecia lateral. Genus: Roccella. The various species of Rocella are the source of the important dye orchil, probably so named from the Florentine merchant who first introduced it and realized a handsome fortune thereby. Only two species occur in Britain, R. tinctoria and R. fuciformis, both growing sparingly on maritime rocks in the extreme south of England and in the Channel Islands. The plants which grow in arid situations in tropical countries are the richest in the colorific principle. In tropical Africa, Asia, and South America, the genus reaches its highest development. Some years ago the average price of orchil ranged from £200 to £400 a ton; but it has been as high as £1000 for the same quantity.

Tribe 7, *Siphulei.* Thallus podetiform, fructification unknown. Genus: Thamnolia.

Tribe 8, *Usneei.* Thallus branched, apothecia peltate. Genus: Usnea. (Fig. 2, A.) Usnea is one of the cosmopolitan genera, but it exhibits many local forms. One species, U. barbata, is widely distributed throughout Britain; and the shaggy grey fleece with which it frequently clothes the older forest trees, especially pines, must have been remarked by the least observing. It is the "beard moss" and "tree moss" of the poets. There are several well-marked varieties, differing in the arrangement of their branches and in their erect or pendulous habit, the most remarkable of which is the variety, or monstrosity, U. articulata, the stems and branches of which are divided into a series of swollen joints, connected by a firm, white medullary thread. U. barbata is used as fodder in northern countries, it is stored up for that purpose in great quantities in North America; it is used to produce an orange dye; in Ray's time it was boiled in beer and the decoction employed in catarrh and dropsy, and it is still a popular remedy for whooping-cough. Some of the species are brilliantly coloured.

Tribe 9, *Ramaliniei.* Thallus branched, apothecia lateral and terminal. Genera: Alectoria, Evernia, Ramalina. Alectoria jubata, "tree" or "rock hair," is dark in colour, and hangs in long, much branched and entangled tufts from trees in lowland and subalpine woods, sometimes to the length of two or three feet. When growing on rocks it is shorter and less rigid. This species is also eaten by the reindeer in winter, the Laplanders unthriftily cutting down the trees to enable the animals to reach it. It yields a red dye. Evernia prunastri had in ancient times a high reputation as an esculent; and it is still used in Egypt to impart a peculiar flavour to bread, being imported from the Greek islands in shiploads for that purpose. There are four British specimens of Ramalina, the most common of which is R. scopulorum, most abundant on rocks by the seashore. The Ramalinas contain a considerable amount of gum, which has been used as a substitute for gum arabic in calico printing, and the whole plant has been employed, in a pulverized form, as the basis of hair powder.

Tribe 10, *Cetrariei.* Thallus compressed, fruticulose or dilated; apothecia marginal. Genera: Cetraria, Platysma. Cetraria Islandica is a well-known lichen, under its officinal name of "Iceland moss." It is employed in this country as an easily digested and restorative diet in sickness or convalescence; it is a most important article of ordinary food to the Icelanders, absolutely taking, says a recent author, among that distant and secluded people the place which the cereals hold in Europe. It is, we are told, exceedingly abundant all over Iceland, attaining a large size on the lava of the western coast. Numerous parties of natives migrate during the summer months with their families and household effects to the places where it abounds, when they collect it in great quantities, both for home use and for exportation. Four tons of the lichen are considered by them of greater value than a ton of wheat. It is chiefly used mixed with flour, but it is also boiled in broth in the same way as potherbs with us. Sir George Mackenzie, while travelling in Iceland, found it very palatable, and other travellers speak gratefully of an agreeable mixture of cetraria with sugar, lemon-peel, and butter or oil. Both in Lapland and Iceland the natives have discovered a simple and effective plan of removing the bitter taste which this lichen possesses in common with the most of its kind, the product being something like starch in appearance, and when cooled after boiling becoming a tough, transparent jelly, pleasant to the taste and nourishing. This starchy product is used in Germany for dressing the warp of webs, in preference to common paste from wheaten flour, and it has been used for sizing paper. The bitter extractive is employed in tanning and dyeing, in brewing, and in the composition of ships' biscuit, to prevent the attacks of worms. It has also been recommended as a valuable antiscorbutic.

Tribe 11, *Peltigerei.* Apothecia peltiform, Genera: Nephromium, Peltigera, Solorina. There are four species of Peltigera found in Britain, the most noteworthy being P. canina, so called because it formed the basis of Dr. Mead's once famous cure for hydrophobia. Its virtues in that respect are however wholly imaginary. P. apthosa, which grows sparingly in the Highlands, is a popular remedy in Sweden for the thrush in children.

Tribe 12, *Parmelei.* Apothecia with a thalline margin. Genera: Stictina, Sticta, Ricasolia, Parmelia, Physcia. Sticta pulmonacea, a handsome species, is common in Britain, growing on the rugged bark of the oak and other forest trees, occasionally on damp rocks. (Fig. 2, B.) It owes its specific name and former medicinal reputation to a fancied resemblance of the surface of its thallus to the meshlike structure of the lungs. It is used by the peasantry for dyeing yarn of a brownish colour. In tropical countries the Stictas are very large and handsome, one widely distributed throughout the southern hemisphere is of a beautiful golden yellow. The Parmelias, also, are much employed in domestic dyeing. P. perlata, which grows in this country, is extensively imported from the Canary Islands for the manufacture of orchil. P. saxatilis, another lichen common in Britain, has been used for ages for furnishing a brownish red dye for woollens. According to Pennant, the variety omphalodes of this species, formed in the last century an important article of commerce in Scotland. Indeed, it is in this tribe, and in the Lecanorei, that the bulk of the lichens most valuable to the dyer are to be found.

Tribe 13, *Gyrophorei.* Apothecia flexuous and having a proper margin concolorous with the disc. Genus: Umbilicaria. The various species of Umbilicaria growing in the Arctic regions of North America are known to the hardy Canadian hunters as Tripe de Roche, and it was on these that the survivors of the ill-fated overland expedition, led by Sir John Franklin, and Dr., afterwards Sir John, Richardson, attempted to sustain nature in the absence of other food, in making their way homeward over the terrible "Barrens."

Tribe 14, *Lecanorei.* Apothecia with a proper and concolorous margin. Genera: Psoroma, Pannaria, Amphiloma, Squamaria, Placodium, Lecanora, Dirina, Pertusaria, Phlyctis, Thelotrema, Urceolaria. (Fig. 6, C.) The typical genus, Lecanora, especially L. tartarea and L. parella, is the source of the valuable dye-stuff "cudbear," so called from the Christian name of Dr. Cuthbert Gordon, who first introduced it. The first-named species is the "cudbear lichen," and at one time its collection afforded employment to many poor people in the Scottish Highlands and the mountainous districts of the North of England. It is still imported in large quantities from Norway and Sweden. L. parella is similarly used, especially in domestic manufacture. Two foreign species of Lecanora, L. esculenta and affinis, utilized in Asia and Africa as food for man and domestic animals, are interesting from their occasional sudden appearance in great abundance; and some authors have attempted to identify them with the manna on which the Israelites were fed during their wanderings in the Arabian desert. These lichens probably grow with no or a very slight attachment to the soil, and, driven by the wind, have been known to fall like rain in various places, to a depth sometimes of several inches, and in several recorded cases very opportunely. In 1829, during the war between Russia and Persia, there was a great famine in Oroomiah, on the south-west of the Caspian; and one day, during a violent wind, the whole face of the country was covered with one of these lichens, which fell in showers. The sheep ate it greedily, which led the inhabitants to try it, and they ground it and made it into loaves, which proved palatable and, it is said, nourishing. During the siege of Herat also there occurred what was described as a "hail of manna," probably a fall of this lichen. A similar fall took place in 1846 in the Russian Government of Wilna, when the ground was covered several inches deep. Pallas states that a lichen, probably one of those referred to, or a congenerous species, is eaten by the Kirghiz Tartars under the name of "earth bread." One of them, also, is eaten by both men and animals in Algeria.

Tribe 15, *Lecidenei.* Apothecia variable in structure, never with a proper margin. Genera: Lecidea, Odontotrema, Schizoxylon. The most noteworthy species of this tribe is Lecidea geographica, a striking ornament of rocks in hilly districts, the supposed great antiquity of patches of which has been already referred to.

Tribe 16, *Graphidei.* Apothecia oblong, furrow-shaped. Genera: Xylographa, Ptychographa, Agyrium, Lithographa, Opegrapha, Platygrapha, Stigmatidium, Arthonia, Graphis, Chiodecton, Glyphis, Melaspilea. The greater number of the genera composing this tribe were formerly included in one—Graphis. The apothecia are generally linear and black, and the fructification in many species bears a striking resemblance to Hebrew or Chinese writing. Several are not uncommon in this country, one, a very handsome one—Graphis elegans (Fig. 6, A), often spreads its mystic characters over the smooth bark of the holly. With us they grow mostly on the bark of trees; in hot climates, like many other lichens, they are found on their leaves. It was an epiphyllous species which struck with astonishment the Lazarist monks, Huc and Gabet, who in the record of their journey to the capital of the Grand Lama, give a description of a marvellous tree they encountered near the town of Koumboum, in Tibet, denominated by the natives "the tree of ten thousand images." "Our eyes," say the travellers (on entering

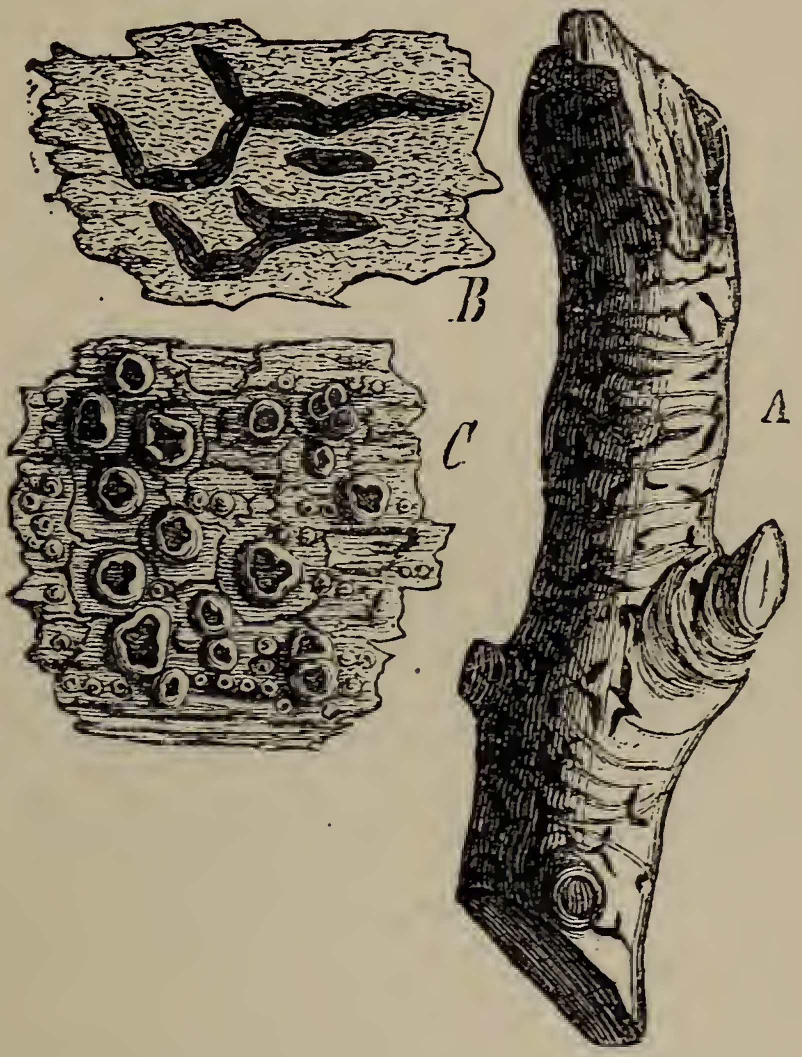

Fig. 6.—*A*, Graphis elegans on bark of holly, natural size. *B*, slightly magnified. *C*, Pertusaria Wulfenii, also slightly magnified.

the enclosure in which it stands), "were directed with the utmost curiosity to the leaves, and we were filled with an absolute consternation of astonishment at finding that, in point of fact, there were upon the leaves well-formed Tibetan characters, all of a green colour, some darker, some lighter, than the tree itself.' Naturally they at once suspected a pious fraud on the part of the Buddhist bonzes; but after a minute examination of every detail, they failed to discover "the least deception." And no wonder, for the mysterious scroll was Nature's own handwriting, being simply the lirellæ of a leaf-borne lichen of the Graphidean tribe.

Tribe 17, *Pyrenocarpei.* Apothecium globular or knot-like. Genera: Thelocarpon, Normandina, Endocarpon, Verrucaria, Strigula, Melanotheca, Astrothelium. Several species of this tribe appear to have a close affinity to the Fungi, others to the Hepaticæ.

The number of British species described under the above genera in the Lichen Flora is about 1,130, with some 570 varieties. Mudd in the "Manual of British Lichens," and Crombie in "Lichenes Britannici," a few years earlier, estimated the British species, the former at only 475 and the latter at 658. It is, however, understood that Mr. Crombie's British Museum Catalogue will contain more species than the Lichen Flora.

No certain traces of the presence of lichens have been discovered in any geological formation antecedent to the Tertiary. Their absence from the earlier strata may, however, be partly accounted for by the nature of their site, and more by their liability to be disorganised by the action of water. Berkeley states that he has known herbarium specimens completely decomposed by remaining in a constantly damp atmosphere. But plants of this order, of existing genera, and identical with, or nearly allied to existing species, have been found in amber and lignites of Tertiary age. In amber there have been detected portions of two species of Parmelia, of Sphærophoron coralloides, Cladonia divaricata, Cladonia furcata, two varieties of Ramalina calicaris, Alectoria aculeata, and a variety of that species resembling the existing A. pubescens, A. ochroleuca and a variety approaching A. succinea, and Usnea barbata, var. hirta; all, or nearly all, existing at the present day. Three existing species have been found in Tertiary lignites. Many of the present species, perhaps some of the now living individuals, have existed from the Pleistocene. The Rev. Hugh Macmillan, in "Foot-notes from the Page of Nature," states that he found a tartareous species growing on the summit of Schiehallion, in Perthshire, on smooth quartz rocks, polished and fluted by glacial action; and that he found these markings, where the rocks were covered by the lichen, as distinct and unchanged by atmospheric disintegration as if the glacier had only yesterday passed over them. This lichen, the first and sole organic covering of the rock, may thus, he suggests, have lived since, or very shortly after the glacial period. The same writer records the occurrence of another lichen, Verrucaria Hookeri, growing in crevices of the highest rocks on the summit of Ben Lawers, and there alone on the globe, as old an inhabitant, probably, as the Lecidea, and apparently yielding, however slowly, to the common fate; for species as well as individuals have their appointed term. The Rev. James Crombie shows that the boreal flora of this country, including, of course, its arctic or sub-arctic lichens, must have been introduced during the glacial period, when the summits of the Scottish Alps were members of a chain of islands extending to the area of Norway through a glacial ocean, seeds and spores being carried over by the winds, on floating icebergs, or by the agency of wandering arctic seabirds.

Lichens are amongst the first, if not the earliest, plants that appear on the cooled lava or the newly elevated coral reef. Schouw, speaking from personal observation, states this to be the case as regards Etna, and in like manner Stereocaulon paschale, a frequent form in Britain, has been observed to be the first plant which settles on the bare lava of Vesuvius and Ischia. Alike in geographical range and in altitude, lichens constitute the outposts of vegetation, growing even above the snow line on the mountains; while on Deception Island, the Ultima Thule of the Antarctic regions, in lat. 64° S., Lieutenant Kendal found no vegetation except "a small sort of lichen struggling for existence." Within the Arctic zone Cladonia and Stereocaulon cover large tracts in immense abundance, to the exclusion of almost every other plant; but the numbers of individuals decrease as the warmer regions are approached, although both in size and number of species the tropical excels both the arctic and temperate zones. The saxicolous lichens are most abundant in temperate countries, the foliaceous prevail in the tropical forests. Making allowance for their propensity to vary in appearance under varying conditions, a great number of species—more, proportionately, than in any other order of plants, may be regarded as cosmopolitan. Amongst others, Usnea barbata, Cladonia pyxidata, and Lecanora subfusca are found all over the world, and Sir J. Hooker observed many of our most common lichens in the Antarctic islands. Of the Australian species, according to Robert Brown, two-thirds are natives of Europe, and something of the same kind is stated, on the highest authority, of the American and Arctic lichen floras. The following view, by Leighton, of the geographical distribution of lichens according to tribes is curious and interesting :—

Byssacei, entirely in the temperate zone; Lichinei, temperate; Collemei, temperate, very few tropical; Myrangiei, temperate, arctic, and tropical; Caliciei, temperate, few tropical; Spherophorei, temperate, very few tropical; Bæomycei, temperate and tropical; Cladoniei, arctic, temperate, decreasing towards the tropics; Stereocaulei, temperate and arctic, especially decreasing towards the tropics; Roccellei, temperate and tropical; Siphulei, temperate and tropical; Usneei, cosmopolitan; Ramalinei, cosmopolitan; Cetrariei, arctic, temperate, few in the tropics; Peltigerei, temperate, arctic, few in tropics; Parmeliei, temperate, arctic, decreasing in number in the tropics, but there attaining their maximum development in the Stictei; Gyrophorei, arctic, temperate, decreasing towards the tropics; Lecanorei, chiefly temperate, arctic numerous, and tropics; Lecideinei, chiefly temperate, numerous in arctic and tropical regions; Graphidei, chiefly temperate, few arctic, numerous tropical; Peridiei, temperate; Pyrenocarpei, chiefly temperate, arctic many, comparatively less numerous in the tropics.

Lichens, as has been already stated, are found at greater altitudes than any other plants, occurring on exposed rocks even above the snow line, which bounds, on its upper frontier, what is known as the lichen zone, a region of desolation still more cheerless than the expanse of eternal winter beyond. The appearance of the lichen zone of the pass of the Great St. Bernard is thus vividly pourtrayed by Macmillan in his "Holidays on High Lands." "The reindeer moss of Lapland," he says, "whitened the ground here and there, interspersed with a sulphur-coloured lichen which grows sparingly on the tops of the Cairngorum range. Large patches of the black Tripe de Roche clung to the stones, looking like fragments of charred parchment, while an immense quantity of other well-known arctic lichens and mosses covered the level surface of each exposed rock as with a crisp, shaggy mantle that crunched under the feet. There were no tufts of grass, no green thing whatever." The gloomy aspect of the plants of the lichen zone is further referred to by the same author in a sketch of the vegetation of the mountain peaks of the Highlands, in which he says that most of the lichens and mosses of these summits are dark-coloured as if scorched by the fierce, unmitigated glare of the sunlight, adding, "This gloomy Plutonian vegetation gives a very singular appearance to the scenery, as in the case of the summit of Ben Nevis, where almost every stone and rock is blackened by large masses of Andræas, Gyrophoras and Parmelias." Some lichens appear able to endure great variations in altitude. Leighton mentions that Cetraria Islandica and C. aculeata occur, the latter fruiting plentifully, at stations in Norfolk and Lincolnshire, probably brought there, he suggests, in a glacial era and surviving the retreat of the glacier. Physcia flavicans has been found on the Kiang-la mountains, at an elevation of 22,000 feet, and by Sir J. Hooker at nearly the same altitude (18,590 feet) on the Himalayas. The same species occurs in the New Forest.

Excepting in densely populated manufacturing districts, and in the immediate vicinity of the Metropolis and other great cities, the lichen student will find no lack of subjects, although it is in the most picturesque and healthful regions that they most abound—on the rocky seashore, on the borders of woods, on upland moor and mountain. Incidentally the habitats of many species have been already indicated ; but the collector may be directed to the examination of trees, solitary or growing on the northern or north-western skirts of woods, decayed stumps and palings, for the corticulous kinds. Of the saxicolous lichens several are peculiar to certain descriptions of rock, some only or chiefly growing on sandstone or calcareous rock, others on granite. Sandstone is the favourite habitat of the greater number ; but all are comparatively rare on basalt. As in the other departments of cryptogamic botany, the lichen collector requires nothing costly or complicated in the way of equipment, a strong, sharp, flat-bladed, clasp or sheath knife, to detach those growing on trees and palings, and a geological hammer and well-tempered chisel to split off a slice of rock as thin as practicable along with the saxicolous kinds, being the sole apparatus absolutely required. The specimens, wrapped in soft paper, and duly labelled on the spot, may then be deposited in a haversack or vasculum. In travelling, if the specimens of foliaceous species are immersed for a short time in water they become quite pliable, and may then be tightly screwed up in paper without injury; but care should be taken that they do not become mouldy. Steeping in water, however, it should be remembered, alters in some cases the characters of the thallus and changes the colour of the apothecia. It is also advisable when convenient to collect them in dry weather, although they are then most difficult to detach; for besides the effect of moisture in rendering them not so easily distinguished, the pressure of the water they have absorbed on the dry asci often causes the ejection of the spores. The usual method of preparing specimens for the herbarium is to press the fruticulose and foliaceous species in the same way as flowering plants. Many species growing on bark and wood, and all the crustaceous rock-growing species, are so attached to or incorporated with their bases of support, that a portion of these must be removed with them. The author of the "Lichen Flora" recommends the course adopted by himself of glueing down each individual specimen to a piece of paper of convenient size immediately on the collector's return home, with names, date of collection, collector's name, etc., noted on them. In the British Museum of Natural History, South Kensington, the plants are glued down to the herbarium folios in the same way as the other plants. Collectors who follow this plan of mounting, however, usually keep the saxicolous species with their bases of rock wrapped in paper and placed in drawers in the same way as geological specimens. Another plan is to glue the specimens on cardboard trays, such as those described in the "Handbook of Shells" in this series, allowing them to dry without pressure, and afterwards arranging the trays or boxes on their edges, the name of the species, etc., being written on the uppermost edge of the tray, and the whole arranged in partitioned drawers. Mr. Leighton, who possesses one of the largest private collections in existence, fastens with pins the squares of paper to which his specimens are attached to quarto sheets of stout cartridge paper. These single sheets are then placed in cartridge sheets folded quarto size, and each genus or section of a large genus enclosed in a portfolio constructed of a quarto cover of thick pasteboard, marked with the name of the genus on the back, and placed on shelves in a book-case or cabinet.

For the examination of the external characters of lichens a pocket lens is all that is necessary; the elucidation of the internal structure of the thallus, and that of the apothecia requires a compound microscope with at least a quarter-inch objective and a B eyepiece. To examine the apothecia a thin vertical section must be made with a keen razor, and the section transferred to a slide or compressorium. The application of a drop of hydrate of potash at this stage will assist in loosening the cohesion of the parts and swell the spores to their proper shape. Then bring down the cover or covering glass, and apply as much pressure as may be found necessary, when, under the power indicated above, a view will be obtained of the asci, spores, paraphyses, and structure and colour of the hypothecium. To facilitate the examination of both thallus and fruit, the employment of chemical reagents has been found very useful. Sulphuric and other mineral acids are employed to disassociate the thecæ and paraphyses, and boiling has been used to facilitate the making of a section or to produce a disaggregation of tissue. Other chemical substances are employed on account of the colour they strike with the cellulose, amylaceous and other matters composing the constituent cells of the tissues. The most important of these is iodine, which ought to be used in very small quantities and much diluted. When thus applied to a section of the apothecium, the thecæ assume a rich blue colour, so that they may be sometimes discerned by the naked eye, while the spore sac and its contents are generally tinged orange or yellow. Even the spore sac, notwithstanding its extreme tenuity, has sometimes by this process been rendered distinctly visible ; the spermatia also become more distinct, as also do the cells of the thallus and their contents. Microscopic sections of the thallus and apothecia, preserved in cells ready for examination, are of great convenience. They should be prepared according to the directions given in the "Handbook of Sea-weeds." Microscopic drawings of spores and sections of the thallus and apothecia, etc., will also be found very useful. They should be attached to the sheets along with the specimens they illustrate.

Besides what is contained in general botanical text-books, a good deal of information on lichens is to be found dispersed throughout the "Transactions" of the Linnean and other scientific societies, and natural history periodicals, those especially of recent date. The section of Berkeley's "Introduction to Cryptogamic Botany," treating of the order, and Dr. Lauder-Lindsay's "Popular History of British Lichens," will well repay perusal ; but the classification followed in both is out of date. The best systematic manual for the British species is the third edition of Leighton's "Lichen Flora of the British Isles." A British Museum Catalogue of these by the Rev. James Crombie, one of our foremost lichenologists, now in course of preparation, will doubtless prove very serviceable to the student.

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MOSSES,

SCALE-MOSSES AND LIVERWORTS.

BY

PETER GRAY.

HANDBOOK OF MOSSES.

Mosses (Musci) are a group of cryptogamous plants, small in size, sometimes almost microscopic, furnished with leafy appendages (not true leaves) arranged upon a distinct axis of growth, and distinguished, in common with the next order (Hepaticæ), by a well-defined alternation of generations in their reproduction. They are found in all situations and under every parallel of latitude, although most numerous in the temperate zones. Mosses are of little economic value, the greatest direct benefit they confer on man arising from the share they take in the formation of turbaries, producing peat, a useful fuel in regions where wood or coal is not available. Certain species were formerly employed, during what have been called the dark ages of medicine, in the belief that they possessed astringent or diuretic properties; and the name of one genus (Hypnum) is derived from the fact that the ancient physicians prescribed a pillow, stuffed with one or more of its numerous species, as a remedy for sleeplessness. The Esquimaux utilize a species of Dicranum for their lamp wicks, and Linnæus describes a very comfortable and portable mattress used in Lapland, which is made of the interlacing tufts of *Polytrichum commune*. In the same hyperborean land the bog mosses (Sphagnum) are employed as fodder when the supply of reindeer moss runs short; and in deficient harvests throughout Northern Europe they are ground and mixed with the dough, although their nutritive properties must be extremely small. The Laplanders, again, find the same moss the cleanliest and cosiest wrapping for their newly-born infants; and many a little bird's nest is comfortably lined with a similar material, while the mossy covering of trees and soil shelters hosts of delicate insects from "winter and rough weather," as well as from the assaults of their natural enemies. If, however, mosses are of comparatively little direct use to man or beast, in the general economy of nature they are all-important. The imaginative Linnæus styled them *servi* or labourers, because they prepare the soil required for the sustenance of the higher orders of plants, and also protect it from the effects of excessive evaporation. Sphagna occupy an immense extent of marsh land in the northern hemisphere, and by their means a higher vegetation is gradually established. Sedges and grasses first establish themselves on the partially consolidated bog, to be followed by cranberry, heath and similar plants. Dwarf willows succeed, and ultimately pine and beech forests take the place of the desolate marsh. Lichens are usually the first plants to establish themselves on bare rock surfaces, and thus prepare a place for mosses; though Lindley reminds us that the first green coat on the volcanic cinders of Ascension Island consisted of minute mosses, and that the black and lifeless soil of New South Shetland is covered with specks of mosses struggling for existence. Whether first in the field or not, they undoubtedly do much the largest part in the work of thus preparing the soil. Experiments made by Mr. Lees at Malvern, show the importance of this function of mosses. That gentleman gathered a tuft of Bryum capillare of between two and three year's growth, from the roof of an out-house at Malvern Wells. The moss weighed altogether six ounces; but when, after repeated washings, he had separated all or nearly all the black earth that enveloped its roots, the actual residuum of stem and leaf weighed only half an ounce, thus showing that the moss had, in the very short space of time indicated, formed from the atmosphere (or accumulated) a quantity of soil above ten times its own weight. Thus, observes Mr. Lees, a bare rock may, in the course of a very few years, be covered with a sufficiently thick coating of earth for the growth of flowering plants. A congener of B. capillare, B. hornum is also a great accumulator of soil in marshy spots; while the growth of such mosses as Sphagnum, Leucobryum, and some Hypna, in the course of time entirely fills up bogs, drinks up their moisture, and thus conduces to their ultimate fitness for profitable cultivation. Indeed Mr. Lees holds it to be probable that it was by such means that the Malvern Hills originally acquired the rich soil which renders them, even in the steepest places, capable of immediate and highly profitable tillage. A considerable part of this soil is however undoubtedly formed from the dust intercepted by the foliage of these small plants, and afterwards washed down by the rain.

Mosses vary much in size. In some cases the whole plant is scarcely more than a line high. On the other hand *Polytrichum* *commune* is occasionally found over a foot in height, while plants of Sphagnum have been observed three yards long, and various Hypna extend their branches to a considerable length. Fontinalis is also found in very long patches. The stem of mosses consists of elongated cells, some of which show a spiral structure, and in some few instances scalariform, or ladder-like, markings. The stem is densest in the centre, which in some of the tall Polytrichums becomes hard and almost like wood. The stems of mosses are simple or variously branched, erect or prostrate, and leafy ; in some few species they are pendulous. The stem sometimes increases by shoots from the base ; and in the acrocarpous division,—those with terminal fruit, which are most numerous in species,—the plant is frequently renewed, year after year, by what are called innovations, consisting of a new growth, frequently arising immediately beneath the fructification, just as the old stem has matured its fruit and is losing its active vitality.

Mosses have no true roots ; but the rootlets, or root hairs, which spring from all parts of the stem, serve to fix it in the earth, while, as will be seen afterwards, they have an office also in the reproductive system of the plant. They likewise, where they are dense, form a protection against cold ; and in many cases they absorb moisture. Some species growing exclusively upon rocks and trees are attached to their base by a mere flattened disc, while in others, such as Bartramia arcuata, the brown masses of root hairs sometimes become so luxuriant as entirely to cover the foliage. Some, as for example, *Hookeria lucens*, send forth rootlets from every point of their structure, even from the edges and surface of their leaves. In many species the rootlets emit a resinous exudation, forming a granular deposit on their surface, which is of use in attaching the plants to hard bodies, and contributes, in the case of species growing on the sea coast, to the agglutination of sands and the binding of sand dunes.

In the length, direction, and form of their leaves, mosses vary much. Their colours are mostly of a clear green, often shaded with golden brown or different tints of red or purple. Occasionally, as in Sphagnum, Leucobryum, Hypnum stramineum, and others, they are almost or wholly devoid of colour. The leaves of mosses are generally arranged alternately, in a few instances in two rows, or bilaterally. Unlike the leaves of flowering plants, those of mosses are simply extensions of the stem-like frond, and they are consequently persistent. In nearly all cases they consist of a single layer of cells of different sizes ; but usually a more or less broad bundle, consisting of cellular substance, extends as a vein or veins from the base towards the point of the leaf, and sometimes beyond it. The leaves of mosses are always sessile, that is, destitute of a foot-stalk, and attached to the stem by their lower edge; sometimes also folding over and clasping by their sides. They are never divided, but always simple, the only irregularities being more or less distinct serratures at the edges, produced probably by the alternate outgrowth of the marginal cells. They are also never found with hairs on the surface, although peculiar outgrowths are sometimes formed on both surfaces; and when the central vein or midrib runs out much beyond the point, the tuft of moss may assume a hairy appearance to the unassisted eye. The border of the leaf is often folded back or inwards, and the whole leaf often convolute. In direction, the leaves of mosses also vary greatly, being crowded and arranged over each other like tiles, or spreading and directed to one or every side. In a few instances organs resembling the stipules of flowering plants are found. The leaves surrounding or enclosing the male organs and fruit generally differ from the others. Mosses are very tenacious of life. A large number, after being totally dried up in summer, recover in the cool and rain of the autumn. In nearly every case, after having been thoroughly dried they revive perfectly on being moistened. In some instances, when quite dry and crumbling between the fingers, they have thus revived on the application of water. This property is of much importance to the collector, who may not be able to examine his specimens soon after being gathered. Even after the lapse of forty years we have moistened specimens which assumed their original form, and a colour scarcely less vivid than they possessed when originally collected.

The fruit of mosses consists of a capsule, theca, or sporangium sessile, or mounted upon a footstalk or seta of greater or less length, crowning the summit of which is sometimes found an intermediate body called the struma, or apophysis, in a few instances more conspicuous than the capsule and richly coloured, and enclosed at its base by a cluster of leaves differing from those of the stem and branches. The seta is round, more or less smooth on the surface, and of firm consistence. The capsule varies in size, form, and consistence; it is in some genera large in proportion to the plant, but in a great many small and inconspicuous. It is mostly egg-shaped or oblong, but sometimes spherical or pear-shaped, or quadrangular, especially when ripe, as in Polytrichum. The surface is generally smooth, but it is sometimes furrowed, streaked with longitudinal lines, or dotted in various ways. When ripe, it opens in most genera by means of a special lid with a regular horizontal fissure, which separates from its capsule when the spores are ripe. The mouth of the capsule is generally surrounded by one or two rows of teeth, four in number or some multiple of four, and in some species also with an elastic ring. In Andræa, however, the capsule splits into four valves connected at the top, and in Phascum it is indehiscent, that is, does not split in any way. The capsule is covered with a hood (calyptra). This sometimes falls off at an early stage, but in other cases remains until the capsule is mature. It furnishes distinctive characters of considerable importance, in species and even in genera. If it remains nearly entire at the base, it is called mitriform ; if the fissure is one side only, cucullate or dimidiate. The base is sometimes fringed, or furnished with membranous appendages. The surface is even, granulated, scaly, or shiny, and sometimes grooved or ribbed, naked or clothed with erect or drooping threads (fig. 1).

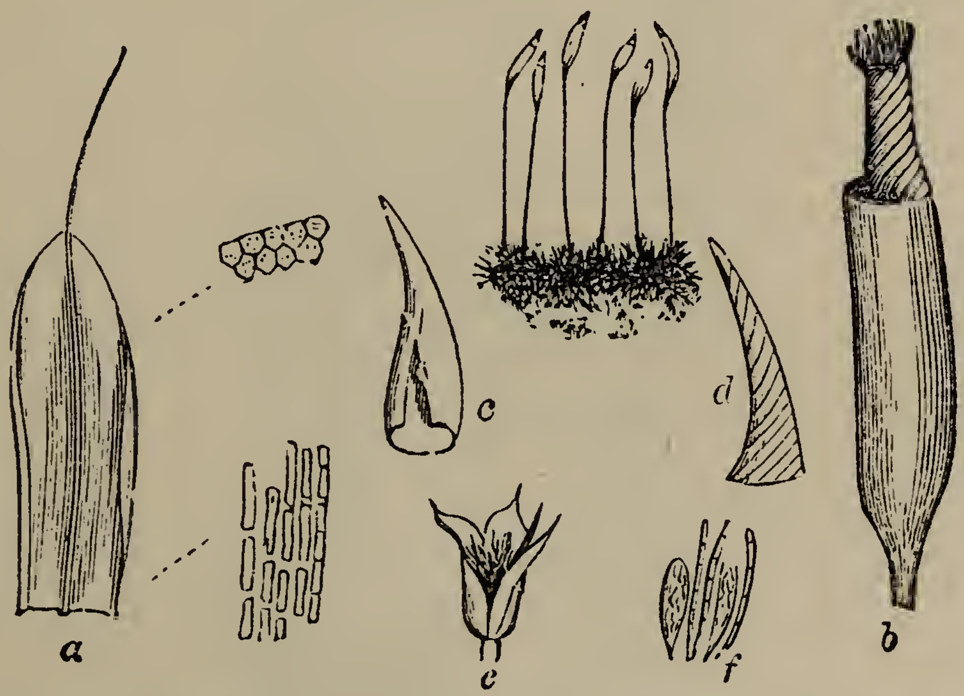

Fig. 1.—Tortula muralis. *a*, leaf and its areolation ; *b*, capsule ; *c*, calyptra ; *d*, twisted peristome ; *e*, male flower ; *f*, antheridia and paraphyses.

The fruit of mosses, from its position in the alternation of generations, is to be regarded as the equivalent of the entire leafy and rooting spore-producing plant of ferns. In the case of ferns, a prothallium bears the generative organs. This, though not persistent, is the analogue of the leafy axis in the mosses, so that the seta and capsule in these are equivalent to the plant-like product of the fern prothallium.

The first stage in the reproduction of mosses consists in the shooting from the spore of a slender jointed thread, resembling the green conferva of our ditches or the spawn of a fungus, and called the protonema. This generally disappears after producing a leafy shoot, out of which the sexual genera-

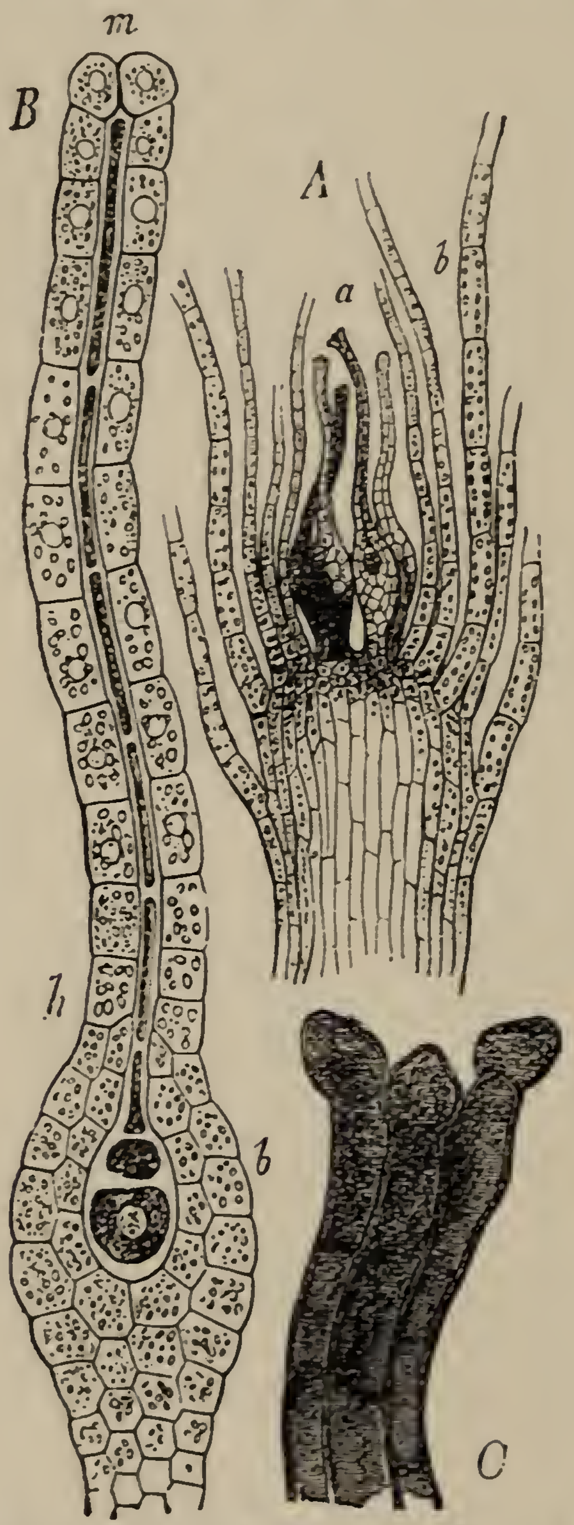

Fig. 2.—Fructification of Funaria hygrometrica. *A*, apex of stem of female plant, magnified 100 diameters; *a*, archegonia; *b*, leaves. *B*, an archegonium, magnified 550 diameters; *b*, base with central cell; *h*, neck; *m*, mouth. *C*, mouth of fertilized archegonium.

tion grows. That consists of the female reproductive organ, called the archegonium, which corresponds to the pistil of a flowering plant, and the male organ (antheridium), the contents of which bear a similar analogy to pollen; and from these arises, as a new generation, the reproductive structure already described, which in its turn produces asexual spores. These organs (archegonia and antheridia) usually occur in considerable numbers, although some of our British species have never been found except in a barren condition. They are produced at the end of leafy shoots, surrounded by leaves usually of peculiar shape, and mixed with paraphyses, which are jointed threads or narrow leaf-like plates formed of cells. Archegonia and antheridia are either found within the same leafy enclosure (synoicous), separate on the same plant (monoicous), or upon different plants (dioicous); and this difference in arrangement is often found useful in discriminating between nearly allied species. The collection of female organs is enclosed in a bud, the constituent leaves of which (perigonial leaves) do not differ so much from the other leaves of the plant as those round the male flowers when these are separate and enclosed in a similar bud. The male flowers, when they are distinct, are sometimes borne on a naked stem; but where perigonial leaves accompany them, these differ considerably from the leaves of the stem and branches (fig. 2).

The cell from which the sporangium or fruit is ultimately developed is formed in the lowest of an axial row of cells lying in the central portion of the archegonium. The antheridia, in mostly all mosses, are sacs of an elongated club shape. Cells containing antherozoids are produced in them; and on the bursting of these cells the antherozoids escape and fertilize the germinal cell. Only one archegonium in each flower is so fertilized, its germinal cell developing into the sporangium, or fruit, which in all mosses consists of a stalk (seta) and the spore capsule (theca), the inner tissue of which develops into spores, a portion of that in the centre remaining as the columella, around which the mother cells containing the spores are formed. The upper portion of the archegonium is torn away by the growth of the sporangium, leaving the lower part surrounding the seta, and forming a membranous sheath (the vaginula), and the upper part becoming the calyptra (fig. 3). The time necessary for the formation of the sporangium varies greatly, but is usually long. The bog Hypna blossom in August and September, and ripen their spores in June of the following year. The species of Funaria are perennially in blossom, their spores being probably two or three months in ripening; Hypnum cupressiforme and some species of Bryum and Polytrichum take a year.

The term of existence of some of the smaller mosses is limited to a few weeks or months; but in most it may be termed unlimited, for their stems continue to grow at the extremities while the older parts die off behind. Thus many mosses, even those which seldom fruit, often form dense masses of vegetation; and they are farther increased by gemmæ, stolons, or detached buds, as well as by the transformation of the root-hairs into the confervoid prothallus or protonema. Gemmæ, analogous to the bulbs of the higher plants, occur in some cases at the summit of a leafless extension of the stem, as in Aulocamnion androgynum; in Tetraphis pellucida they are contained in an elegant cup composed of several leaves; and a species of Orthotrichum, cosmopolitan in its geographical range, which has never been found in fruit, is freely propagated by gemmæ formed at the ends of its leaves. When leaf-buds are detached, they immediately begin

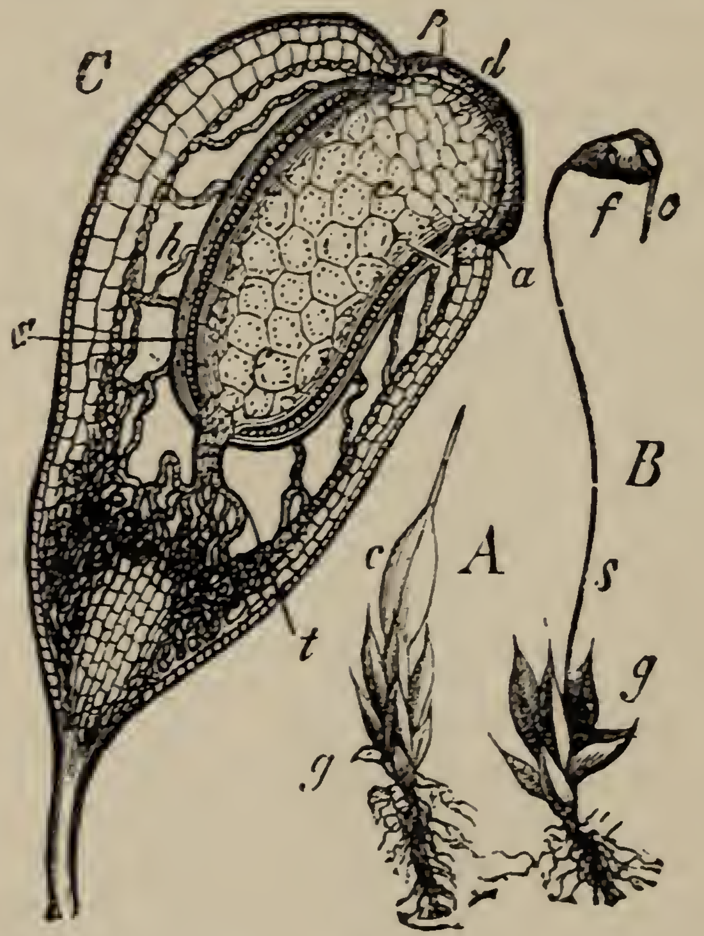

Fig. 3.—Funaria hygrometrica. *A*, a young leafy plant (*g*) with the calyptra (*c*). *B*, a plant (*g*) with the nearly ripe sporangium; *s*, its seta; *f*, the capsule; *c*, the calyptra. *C*, longitudinal section of the capsule, bisecting it symmetrically; *d*, operculum; *a*, annulus; *p*, peristome; *cc*, columella; *h*, air cavity; *s*, the primary mother cell of the spores.

to grow. The root-hairs produce leaf-buds behaving exactly as protonema does ; even the leaves give rise to protonema, which, indeed, every part of a moss seems capable of producing.

In some species of Bryum, Barbula, Leucobryum, etc., if a tuft of the moss is kept damp for some days and turned downwards, it will produce hundreds of new plants. A specimen of the last-named plant, found on Dartmoor, and exhibited in one of the cases in the new Natural History Museum at South Kensington, has thus grown into a circular mass, vegetating from all points of its circumference. Species of Phascum, Funaria, and some other apparently annual mosses, persist perennially by means of root-hairs, the plants disappearing completely from the ground from the time the spores become ripe till the next autumn, when they again produce a new protonema, and on this new stems arise. Thus vegetative reproduction is more copious and varied in the mosses than in any other section of the vegetable kingdom ; and there is this peculiarity about it, that in nearly every case the growth of a new leaf-bearing stem is preceded by the formation of protonema.

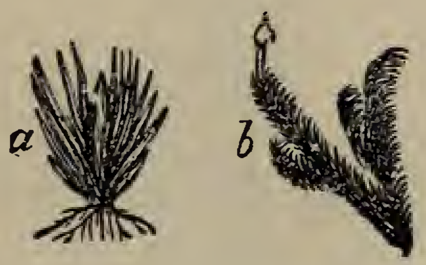

Fig. 4.—Ephemerum (Phascum) serratum slightly magnified. *b*, Andræa.

Much remains to be done in the way of a good and natural classification of mosses, both as regards their greater and lesser divisions. Sachs distributes them into four parallel orders—Sphagnaceæ, consisting of one genus, Sphagnum, the bog mosses ; Andræaceæ, of a genus found in Britain, Andræa, and an Antarctic one, Acroschisma ; Phascaceæ, of one genus, Phascum, mainly distinguished by its indehiscent capsule ; and Bryaceæ, including all the other mosses. This classification is, however, far from perfect ; and it will be more convenient here to follow that employed by Wilson in his great work, the "Bryologia Britannica," which was adopted from that of Bruch and Schimper, in the "Bryologia Europæa," and by which all mosses are divided into five groups or sub-orders : 1. Schistocarpi, with the fruit splitting into valves ; 2. Syncladei, with fasciculate branches ; 3. Acrocarpi, with the fruit terminal ; 4. Cladocarpi, with the fruit terminating short special branchlets; and, 5. Pleurocarpi, with the fruit borne on lateral branchlets.

The first group contains only one tribe or family, Andræceæ, comprising two genera, Andræa and Acroschisma, the former only being native. These mosses externally bear a very close resemblance to the genus Jungermannia among the next order, scale-mosses, in which Andræa was formerly placed ; but the cells differ in structure, and there is a distinct columella in the capsule, which clearly show their true affinity. In one species the valves are free. The species of Andræa in this country all

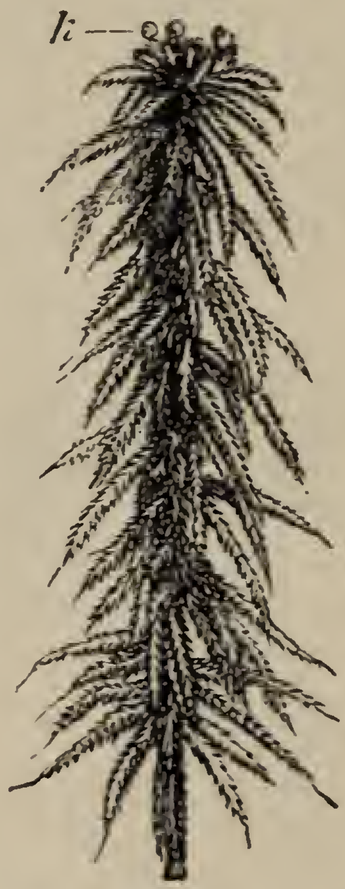

Fig. 5.—Stem of Sphagnum, natural size ; *k*, capsules.

grow on mountain tops, especially in the moist places, and in wide-spreading tufts. They are small plants, and of a dark and dingy green colour (fig. 4, *b*).

The family Syncladei consists of only one genus, the conspicuous and abundant Sphagnum. . Sphagnum, like the plants in the preceding tribe, differs very considerably in structure from the others, its nearest affinities being with that tribe. Besides the fasciculate arrangement of its branches, in which it differs from all other mosses, Sphagnum has a globular sporangium, the calyptra of which is persistent below ; the leaves are light-coloured, white when dry, and the large white cells are perforated and surrounded by narrow green ones ; their protonema also is strikingly different. Another peculiarity is the absence of rootlets. This genus affords great scope for the class of systematists known as "splitters," or species makers. Sir William Hooker divides it into four species, and quotes approvingly the suggestion of Linnæus that there is probably but one. The last edition of the London Catalogue enumerates 16, with some 40 varieties, several of which are ranked as species by authors (fig. 5).

The next sub-order is the most numerous in genera of all. The first family is the Phascei, including the British genus Phascum and a few others. The species of Phascum are numerous and mostly very minute. They are clearly distinguished by their indehiscent capsule (Fig. 4, *a*).

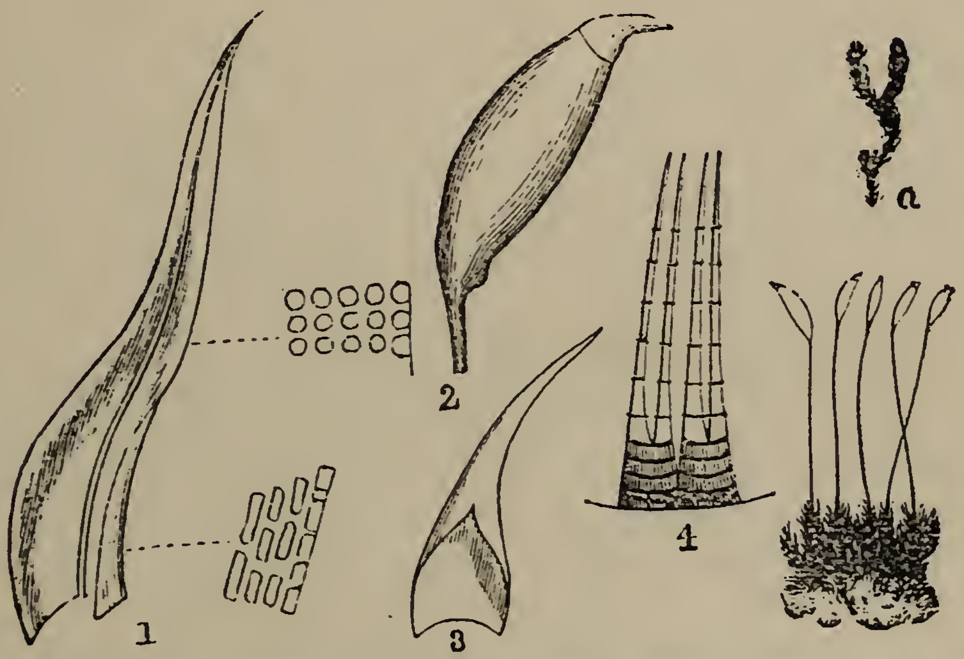

Fig. 6.—Ceratodon purpureus, with leaf, male plant, capsule, calyptra, and two teeth of peristome.

The Weissiei consist of a great number of genera. They are distinguished by their erect sporangium, and by the peristome, when it occurs, possessing sixteen teeth, which are often united at the base, and by their dimidate calyptra. Physcomitrium fasciculare, a British species, occurs in great abundance on walls about Jerusalem, where it was found by the learned botanical traveller, Hasselquist, who, having identified it with the "hyssop that springeth out of the wall" of Solomon, named it Hyssopus Salamonis. Ceratodon purpureus, a member of this family, is perhaps the most widely distributed of all mosses (fig. 6).

The next family, Dicranei, contains some of the most conspicuous, as well as the most common, of British mosses. The sporangium in this tribe is occasionally streaked or furrowed; the peristome single, of sixteen teeth, split half-way down, with a cuculliform or hooded calyptra. Leucobryum glaucum is remarkable for its pallid leaves, resembling those of Sphagnum, with which it is found. Its habit or general appearance is also very similar; and, like Sphagnum, its cells are perforated. The chlorophyll cells are, however, not superficial, as in that species, but imbedded among the coloured ones. L. glaucum is interesting to collectors on account of its rarity in fruit, which, however, is a characteristic of too many of our species. Dicranum majus, the large broom-fork moss, is one of the handsomest of mosses; and the more common form, D. scoparium, is a great ornament to the places where it grows. It is said to be met with in almost every quarter of the globe; and in this country it is found in many different stations. Sandstone rocks, peat bogs, shady banks, and trunks of trees are the favourite haunts of these mosses, many of the smaller species being no less beautiful, when closely examined, than their larger *confrères.*

The next family including British species is the Pottiacei, which resemble the Phascums in a general way, but are separated from them by their pedunculate and dehiscent sporangia. The sporangia are always oval in Pottia, without a peristome, in other genera, with a sixteen-toothed one; the calyptra is mitriform and the cells of the leaves large. They occur, like the Phascei, on newly moved soil, or in corresponding situations.

The Trichostomei constitute, unlike the previous one, a very large tribe, distinguished chiefly by the peristome consisting of thirty-two filiform teeth, frequently approximating in pairs, and in one section spirally twisted. This last character is very conspicuous in the genus Tortula, one species of which is abundant on nearly all wall tops in town or country. Its common name, wall screw-moss, is derived from this peculiarity (fig. 1). Another, T. ruralis, is a common ornament of the thatched roofs of cottages.

The only British species in the Ripariacei order is Cinclidotus fontinaloides, a handsome plant, distinguished by the latticed structure of the lower part of the peristome, the teeth of which, bright red, slender, rigid, and spirally twisted, render the peristome a beautiful object.

Encalyptei contains one genus, Encalypta, also British, the species of which are easily known by their large and peculiarlyshaped calyptra, whence they have obtained the English name of extinguisher moss. They resemble in habit the Tortulæ. The common species, E. vulgaris, is frequent on wall tops in the South, fruiting in the spring, and where in any way abundant is easily detected by the pale green of its cylindrical calyptra, which adheres to it longer than is the case with most other mosses.

In Hedwigiacei the leaves are nerveless and the peristome absent. The order is represented in Britain by Hedwigia, named after the eminent bryologist, John Hedwig.

Grimmiei, the next order calling for notice, is distinguished by the mostly sessile sporangium, the mitriform calyptra, and leaves of a dark green always terminated by a white hair. Grimmia, although small in size, is, owing to its dense masses, a conspicuous object where it occurs.

Racomitrium has somewhat the habit of the pleurocarpous mosses. R. lanuginosus is frequently found on the Scottish mountains in such quantity as to form an elastic grey carpet many acres in extent; and so hardy is it that it is often met with in winter or early spring quite encrusted with snow, and yet bearing its fruit profusely beneath the snowy mantle.

Ptychomitriei consists of only three genera, two of which are represented in these islands by one species each.

In Orthotrichei is collected a large mass of species with widely differing characters. The cognominal genus, together with another recently dissociated from it, numbers some thirty species of tree-loving plants, many of them very handsome. The genus is a "natural" one; that is, its species have much in common, and are therefore difficult of discrimination. The capsule, however, furnishes useful characters or marks by which to distinguish them.

Buxbaumiei contains only two genera, both of which are represented in Britain, and both are peculiar in aspect. Buxbaumia, of which we have two species, has a thick, rough seta, tipped by an apophysis on which is seated obliquely a large capsule, with a small calyptra just covering the lid, so that the plant, which has no evident leaves, looks more like a fungus than a moss. B. aphylla grows in fir woods, and has been found both in Britain and Ireland. Diphyscium foliosum, which has a short stem with large perichætial leaves, and often grows with its capsule downwards, is found on banks, wall-tops, and similar situations in alpine districts. The curious plicate membrane forming its peristome is sufficient to distinguish it from all other mosses.

The next tribe is an important one. The Polytrichei include some of the tallest and finest species and are remarkable for several peculiarities of structure. They are distinguished by the mouth of the sporangium being mostly closed by a flat membrane and by the calyptra being nearly always single with drooping hairs. The genus Polytrichum includes the tallest of British mosses, P. commune, which has been found more than a foot high; but there are foreign species considerably taller. In

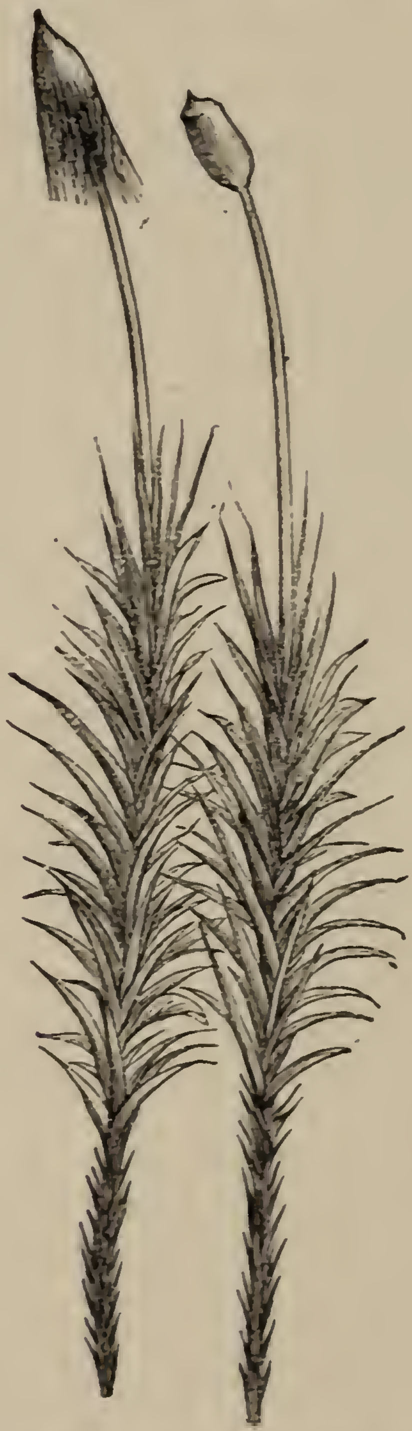

Fig. 7.—Two stems of Polytrichum formosum, showing capsule bare and covered with the large calyptra.

"Lachesis Lapponica," Linnæus gives an interesting account of the use of Polytrichum commune as bedding, which has already received a passing notice. He says :—"The bountiful provision of nature is evinced in supplying mankind with bed and bedding even in the savage wilderness. The great hair moss, called by the Laplanders Romsi, grows copiously in their damp forests and is used for this purpose. They choose the starry-headed plants, out of the tufts of which they cut a surface as large as they please for a bed or bolster, separating it from the earth beneath; and although the shoots are scarcely branched, they are nevertheless so entangled at the roots as not to be separable from each other. This mossy cushion is very soft and elastic, not growing hard by pressure, and if a similar portion of it be made to serve as a coverlet nothing can be more warm and comfortable. I have often made use of it with admiration." "They fold this bed together," he continues, "tying it up into a roll that may be grasped by a man's arms, which, if necessary, they carry with them to the place where they mean to sleep the night following. If it becomes too dry and compressed, its former elasticity is restored by a little moisture."

The Bryei are distinguished by the loose reticulations of their marginal leaves, the regular sporangia, which is generally drooping, and the highly-developed double peristome. Fifty or sixty of the Bryums and closely allied genera are found in Britain, and many of them are very handsome, fruiting, also, copiously. Bryum androgynum, the capsules of which are rare, is compensated by the abundant balls of green gemmæ which rise on short naked stalks all over its stems. Bryum roseum, with its shining rosette of large leaves surmounting the stem, is the largest and most beautiful of all the European species, and one of the most handsome of mosses. It is very rare in fruit, in Britain at least. B. ligulatum, like some other plants and some animals, seems to affect the society of man, growing and fruiting often very luxuriantly in the shady precincts of garden or shrubbery. Bryum argenteum, the silvery thread moss, very frequent on wall tops and similar situations, can hardly escape the notice of the most superficial observer. Its branches have so much the appearance of willow catkins that Dillenius termed it the "catkin-stemmed silver moss."

The species of Meesiei somewhat resemble those of the preceding family. They are all marsh-loving plants, and remarkable for their very long peduncles and sporangia.

The Funariei are distinguished by a curiously inflated calyptra and the loose reticulation of their leaves. Funaria hygrometrica, a well-known British species and cosmopolitan in its range. It is always found in the track of fire, whence its French name, La Charbonnière.

Bartramiei have the sporangium spherical and mostly striated, by which, in conjunction with their peculiar habit, they are easily distinguished. There are six or seven British genera. The species of Bartramia are all elegant, most of all perhaps the well-known B. pomiformis, with its pale-green foliage and neatly globular capsule, popularly known as the "apple-moss." B. fontana, growing by the margins of springs and streams, is also a very beautiful moss. B. arcuata is interesting from the variety of its fruit and abundant rootlets, and also from its being almost entirely confined in habitat to the British Isles.

The Splachnei contain many of the most singular and beautiful of mosses. Splachnum ampullaceum is one of the finest of British species. The most marked feature of the tribe is the swelling at the base of the straight sporangium (apophysis), which in many species is much larger than that organ itself and often brightly coloured. In S. luteum and rubrum, which Berkeley qualifies as the pride of hyperborean Europe and America, the apophyses are of extraordinary size and brilliant colour.

Schistostegei consists of only a single species, Schistostega pennata, which is a native of Britain. It grows on the roofs of sandstone caverns, which it lights up with a golden-green refraction from its protonema. The leaves are in two rows and comparatively large ; and from its resemblance to a miniature fern it has also borne the specific name osmundacea.

The fourth group, which is intermediate between the last and following, contains only a few foreign species.

The last, the Pleurocarpi, comprises thirteen families. The first of these, Anœctangiei, contains only a few species. In the second, Drepanophyllei, well distinguished by its distichous and equitant leaves, occurs the genus Fissidens, formerly included in Dicranum. Fissidens bryoides, common on shady banks all over Britain, which it ornaments with its neat deep-green foliage and abundant capsules, has been generally believed to be the plant the sight of which revived the fainting spirit of the famous African traveller, Mungo Park under exceptionally trying circumstances. While making his way from captivity through the hilly region between the Niger and the Sahara, he was attacked by robbers and left almost naked. His pathetic narrative, though somewhat trite, will bear repetition. "After they were gone," he says, "I sat for some time, looking around me with amazement and terror. I saw myself in the midst of a vast wilderness, in the depth of the rainy season, naked and alone, surrounded by savage animals and by men still more savage. I was five hundred miles from the nearest European settlement. I considered my fate as certain, and that I had no alternative but to lie down and perish." In this extremity the extraordinary beauty of a small moss in fructification caught his eye. He felt that the Being who had planted and watered and brought to perfection a thing of such small apparent importance would not look with unconcern on the situation and sufferings of a creature formed in His own image. "Reflections like these," he adds, "would not allow me to despair. I started up, and, disregarding both hunger and fatigue, travelled forwards, assured that relief was at hand; and I was not disappointed." Park brought a patch of the moss home with him, and gave it to his brother-in-law, from whom it was procured by Sir W. Hooper, who identified it as Dicranum or Fissidens bryoides, variety β, of his Flora. Mr. Mitten, however, an eminent living bryologist, has recently examined this interesting tuft of moss, and considers it to belong to another species, which he has named Fissidens Parkii. It is a smaller plant than F. bryoides, and the fruit is borne on a shorter stalk. Otherwise it is very like the latter: and indeed all or most of this genus bear a strong family resemblance to each other.

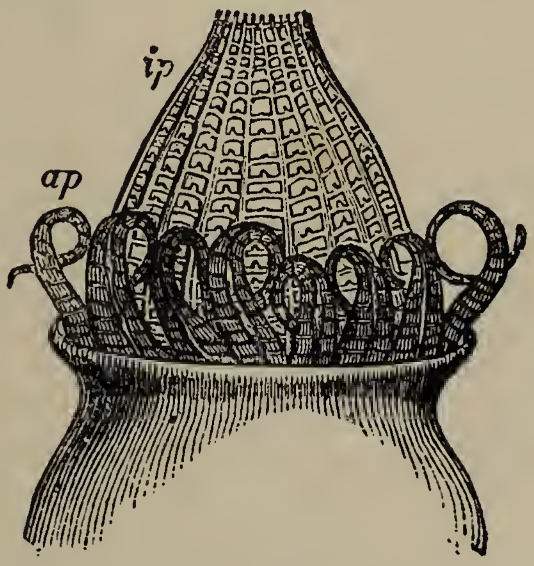

Fig. 8.—Mouth of capsule of Fontinalis antipyretica magnified; *ap*, outer peristome; *ip*, inner peristome.

The tribe Fontinaleii consists of aquatic, floating species, the sporangia of which are enveloped in the perichætial leaves. Fontinalis antipyretica, a common moss in Britain, receives its specific name from the fact that it is used in Sweden to stuff the space between the chimney and the wall, to prevent fire, which it is said to do effectually from its not being inflammable (fig. 8).

Hookeriei have the stems flattened and creeping, with the leaf cells unusually large. Hookeria lucens is one of our most beautiful mosses, and very striking from its large pale, shining green leaves.

Neckerei have also a compressed stem, and our British species are rather conspicuous objects, Neckera crispa especially, which is a very handsome moss.

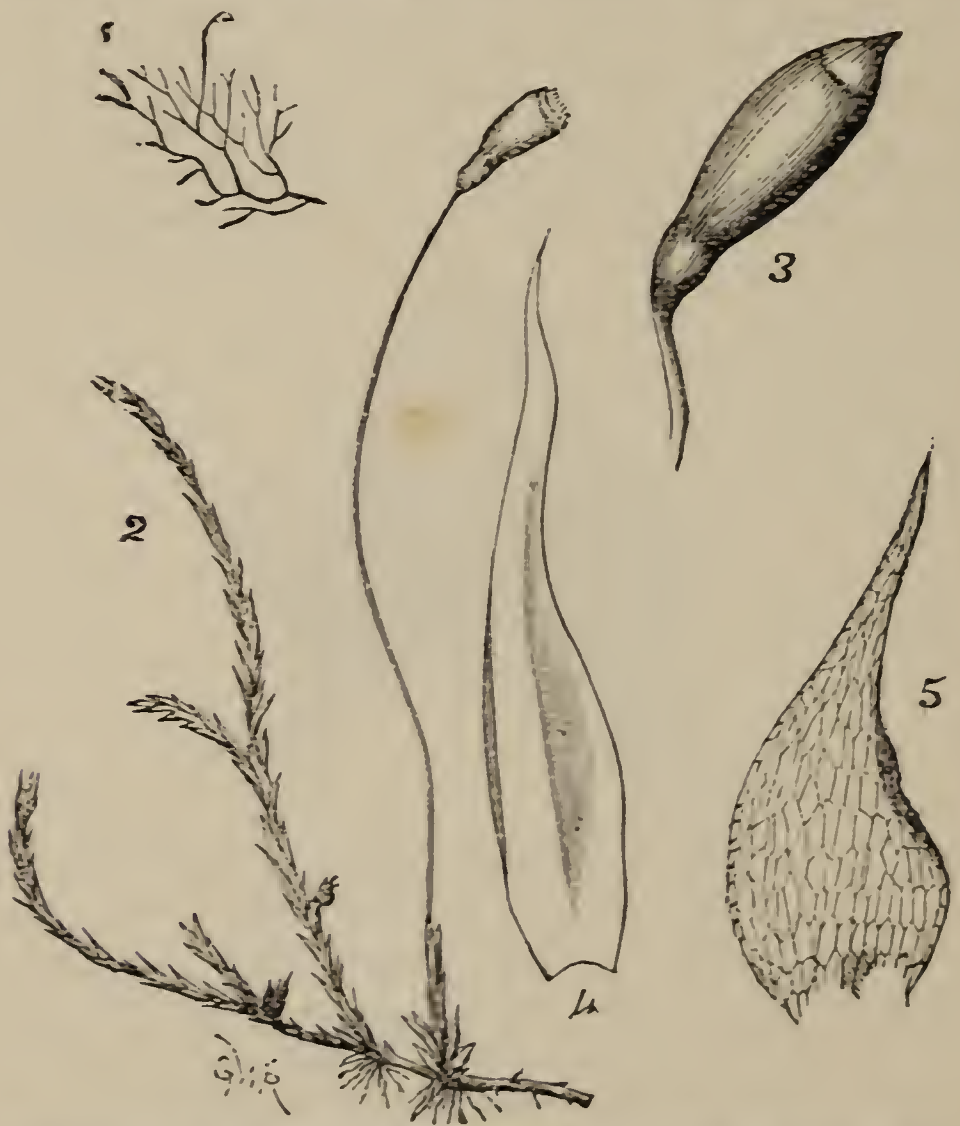

Fig. 9.—Hypnum (Amblystegia) confervoides. 1, plant natural size; 2, magnified; 3, capsule: 4 and 5, leaves.

The Hypnei are a very numerous tribe, not only in genera and species, but in individuals. Hypnum contains more species than any other genus. There are nearly a hundred of them in England alone, and they are estimated to form nearly a fourth of the vegetable clothing of our island (fig. 9)

The Leucodontei are distinguished by their erect sporangia from the Hypnei, which in other external respects they resemble. One of the species, Pterogonium gracile, is indicated by Müller as one of the most beautiful of European mosses. When dry its leaves are closely imbricated, but even a slight application of moisture causes the foliage to expand and spread out horizontally, so that it can scarcely be recognised as the same plant.

The species of mosses are very numerous. About 570 are found in Britain. According to Schimper some 280 occur on the Continent and not in Britain. Twenty continental genera are not included in our insular flora. About a fifth of the New Zealand species are also British. Although most abundant in the two temperate zones, there is scarcely any part of the world without them. Alike over the North American "barrens" and the Siberian tundras, frightful treeless wastes, where the soil never thaws below the depth of a few inches, they constitute almost the only vegetation, while a great many flourish in tropical and sub-tropical regions. Like other cryptogamic plants, the range in space of individual species is often extensive. In Tierra del Fuego, that land of frost and fire, on the extreme south of the American continent, there are to be found forty-eight mosses identical with British species, and almost all the great tribes have representatives in Europe. Grimmia apocarpa, a frequent British form, abounds in both hemispheres, from the Arctic regions to the Falkland Islands, and from California to New Zealand. Bryum ligulatum is also widely distributed, occurring at the Cape of Good Hope and elsewhere in both hemispheres. Hypnum cupressiforme and Ceratodon purpureus are perhaps the most widely distributed of the whole order. Among other species almost cosmopolitan in their range, may be enumerated Andræa rupestris, Weissia controversa, Racomitrium lanuginosum, Funaria hygrometrica, Bryum argenteum, B. capillare, and Polytrichum commune.

Regarded with respect to local, as distinguished from geographical distribution, mosses are to be found at all altitudes, from the lowest swamps and turbaries to the verge of perpetual snow on the bare and tempest-swept mountain tops. Several species of Andræa, Grimmia, and Dicranum with Conostomum boreale, occur on the snow line. The last-named, also a Scottish form, is found in Spain on the tops of the highest sierras; Grimmia atrata, Polytrichum alpestre, and sexangulare, with a few others, reach the snow line on the Alps; and various species of Andræa attain a similar elevation on the Scandinavian peninsula. Many species grow indifferently on any soil or situation, but most affect certain soils more than others. Bartramia pomiformis, Bartramia Halleriana, with various Hypna and Grimmiæ, choose the granitic *débris* of subalpine heights; others again delight in dusty roadside walls and arid soils. The partiality of Funaria hygrometrica to burnt ground has already been noticed. Several species are mostly found on the borders of ditches; and most numerous of all are those which prefer the shady covert of woods, growing either on the soil or on trees. The boulders scattered over the German plains produce arctic species which never fruit there, and have perhaps been brought during the glacial period from the higher regions. A few mosses only are aquatic. One, Schistidium maritimum, is remarkable for choosing situations continually exposed to the salt sea spray. They are mostly all social plants.

Then, as to their distribution in time, although it is highly probable that mosses may have existed much earlier, it is not to be wondered at, when their delicate cellular structure is considered, that no remains of them have actually been discovered before the middle Tertiary. Examples of ten genera have been found in tertiary strata, nine of which still exist, and about forty species. Nearer our own time, remains of Sphagna have been detected in Pleistocene lignite; and Phascum cuspidatum and Dicranum fuscescens, both living British species, several other Dicrana, and various species of Weissia and Polytrichum, have been met with enclosed in amber. A great many species now living in Britain have been found in the post-glacial deposits of southern Sweden and Norway, their succession indicating the changes of climate between the glacial period and the present day; and a species now confined to the arctic regions has been found in the Post-pliocene strata of England.

The liverworts and scale mosses (Hepaticæ) are very closely related to the Musci, with which, under the common appellation of bryophytes, they have been classed. They are minute, green, creeping plants, sometimes possessing a stem with leaves, and then resembling mosses; at others, with a flat expanded stem, when they bear a superficial resemblance to lichens. But the whole plant is softer and more wavy and transparent than the mosses, and the colour and texture of both the frondose and thalloid species are sufficient, even when they are not in fruit, to distinguish them. Their intimate relationship with mosses is shown in their reproductive organs; but the capsule in the Hepaticæ does not in any instance open by a special lid; it always contains elastic threads which assist in the dispersion of the spores (fig. 12), and, except in one small tribe, there is no columella; while the calyptra remains at the base of the capsule. Unless for their convenience in studying vegetable structure, and the beauty of form and tint under the microscope which they display, none of them have any known uses. In former times certain kinds of Marchantia were considered specific remedies in diseases of the liver, but for no better reason than the shape of their fronds. Old Gerard gives figures of a Marchantia, which he describes, with his accustomed quaintness, as being often found in "shadowy and moist places," where "the sunbeams do seldom come, and where no traveller frequenteth," "bringing forth its blazing stars and leaves oftentimes in June and July," adding, "It is named in shops hepatica, yet there are also many other herbs named hepatica, or liverworts, for difference whereof this may fitly be called Hepatica petræa, or stone liverwort, having that name from the German." He goes on to say that "it is singular good against inflammations of the liver, hot and sharp agues, and tertians," and quotes Dioscorides to prove that it has other useful medi-

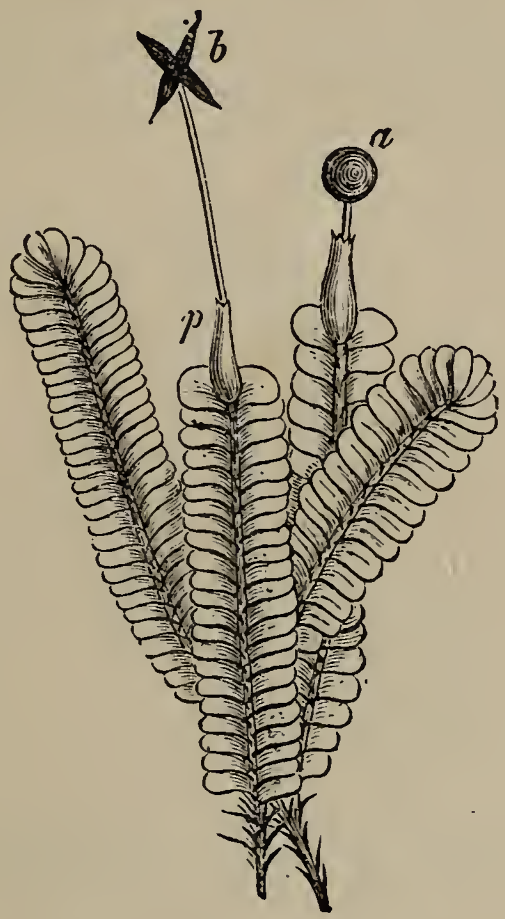

Fig. 10.—Stem of Plagiochila (Jungermannia) asplenioides. *a*, ripe capsule; *b*, one that has opened; *p*, perianth.

cinal qualities. Several liverworts have a pungent taste, and Dr. Carrington says that the musky odour observable in woods and fields after rain, and generally attributed to the smell of moist earth, is really emitted by these plants, some of which have a strong musky scent.

The Hepaticæ may be classed in four groups, or sub-orders, viz., Jungermanniaceæ, Marchantiaceæ, Ricciaceæ, and Anthoceroteæ, which we shall now proceed briefly to describe.

The first division, in its foliose members, approaches the mosses in Andræa. The plants included in it have in most cases slender, thread-like, creeping stems, like those of the branched mosses, bearing numerous sessile leaves, usually in two rows, one on each side and over or underlapping each other; but occasionally there is an additional row on the under surface, differing from the others in shape (amphigastria). In the expanded leaf or thalloid forms, though there are no stem leaves the branches are bilaterally arranged, and there are transitional forms where a flat thalloid stem produces leaves on the under or on both surfaces. The reproductive organs in this tribe are, in the flattened genera, formed on the upper side and near the middle of the frond; in the leafy division, at the end of special small branches. In these the archegonia are often produced in large numbers, the branches in which they originate being sometimes hollowed out, so that the archegonia appear as if sunk in a deep hollow; but they are usually surrounded by perichætial leaves as in the mosses. The sporogonium, originating in

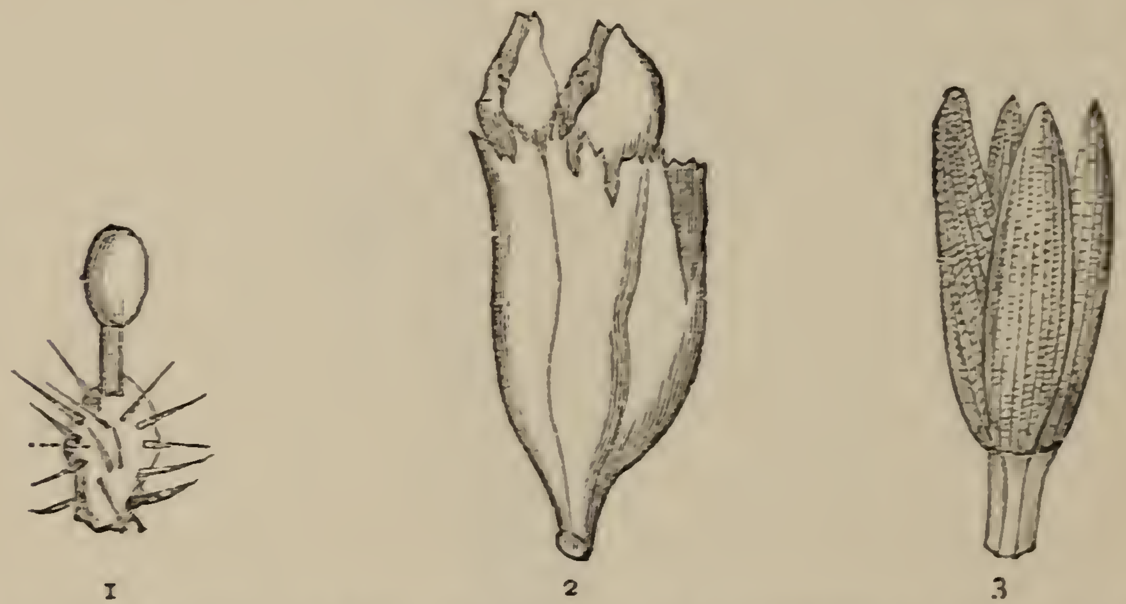

Fig. 11.—1, spinous calyptra, and capsule of Jungermannia; 2, calyx and burst capsule; 3, capsule, burst into four lobes.

different ways in the archegonium, develops in the same way as in the mosses, only no part is raised with it as a calyptra; the vaginula, which consists of the entire archegonial sac, receiving that name. As is also the case throughout the whole order, as well as in the mosses, only one of the archegonia is fertilized, after which it enlarges and the sporangium remains at the bottom of the perianth until the spores are ripe, differing from the mosses in that respect. The antheridium varies greatly throughout the order. It is most moss-like in Jungermanniaceæ, consisting of a footstalk with a round body at the summit, filled with mother cells of antherozoids, which latter, when set free, have the appearance of spirally curved slender threads, with two

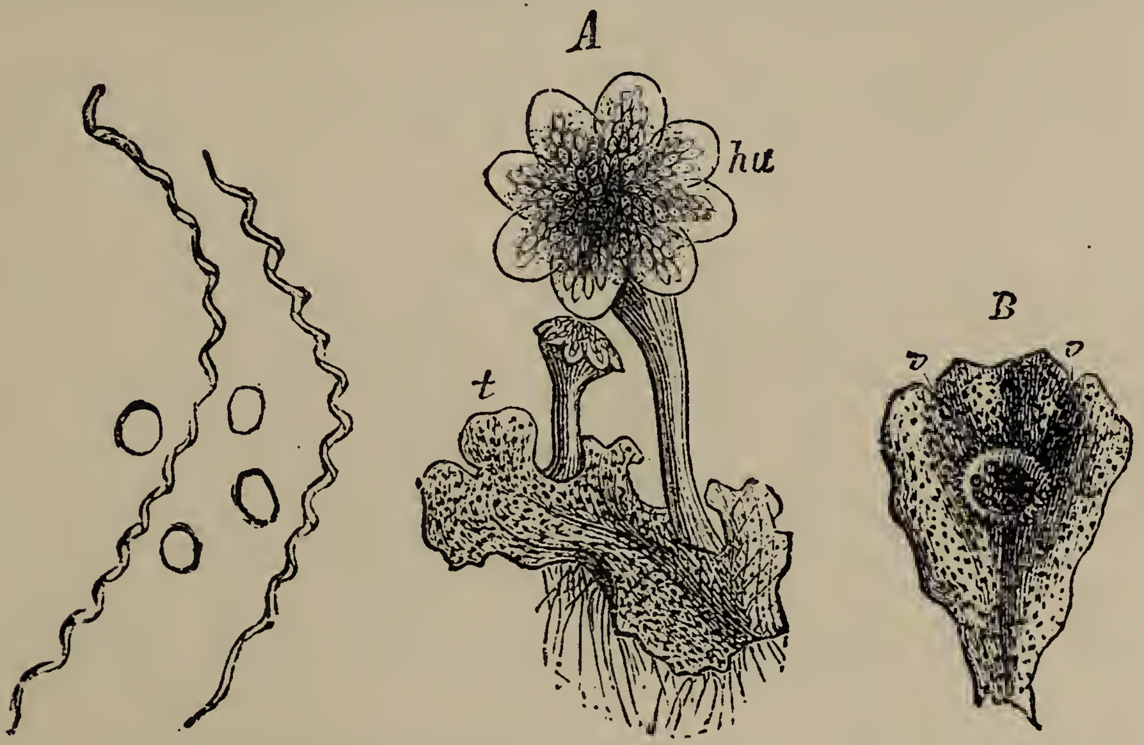

Fig. 12.—Elaters of Jungermannia, elastic threads aiding in the dispersion of the spores. *A*, portion of a stem of Marchantia polymorpha with the male receptacle. *B*, portion of stem with a receptacle containing gemmæ.

long and very fine cilia at their foremost end, by means of which they move in fluid (figs. 10 and 11).

The Marchantiaceæ have a flat, ribbon-like stem, branched in a forked manner, having a midrib and being composed of several layers of cells. The epidermis, skin, or bark of the upper side is penetrated by large stomata, or breathing apertures, communicating with which are also large air cavities. The reproductive organs in this group, as in the preceding one, are situated either on the same or on different plants (monoicous or dioicous). They vary very much, both in form and in the structures upon which they are borne. The antheridia in

Marchantia, which may be taken as a type of the group, are immersed in a shield-like receptacle. The sporangium is usually shortly stalked, and bursts at the summit into four lobes, or into numerous teeth. Sometimes the upper portion becomes detached as an operculum (fig. 12).

In their vegetative part the Ricciaceæ resemble the Marchantiaceæ. Some of them are aquatic. They have large air-cells in their substance, but no stomata in the epidermis. The archegonia and antheridia are formed in the upper side of the leaf from cells which grow into soft tubercles, and which are ultimately overarched by the surrounding tissue. The archegonia become in the end similarly arched over, a globular sporangium is developed from the fertilized oospore, the contents of the sporangium being set free by the decay of their envelope.

Anthoceroteæ are found in loamy ground. In them the frond is flat and leafless, irregularly branched, and with a circular extension. It is composed of several layers of cells, and bears stomata on the under side. On impregnation the sporangia elongate into a pod-shaped organ, the sides of which split into two valves, leaving a columella in the centre (fig. 13).

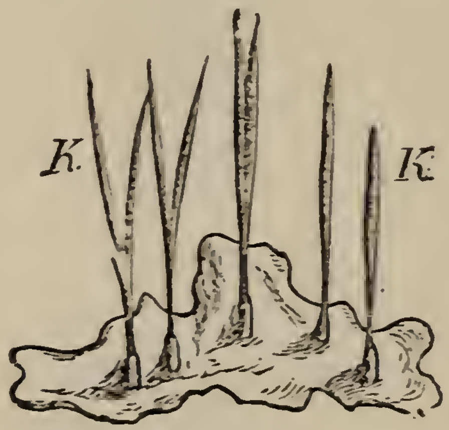

Fig. 13.—Anthoceros levis (natural size). *K*, the capsules, some as yet unopened.

Besides the essential fruit, many hepaticæ are also largely propagated by gemmæ, situated, sometimes on distinct stalks, sometimes on the tips or margins of the leaves, and sometimes in cup or crescent-shaped receptacles. As in mosses, the frond sometimes dies off behind, the branches thus becoming independent plants. Adventitious branches are detached in the same way. In decayed and apparently withered fronds, certain cells after a period of rest assume new activity and multiply so as to give rise to new plants.

Hepaticæ are found in every part of the world, growing in moist shady places, on the ground, on trees, and sometimes on leaves, luxuriating most in warm climates, especially where there is a tolerably uniform temperature. About eight hundred species are known, one hundred and ninety-two of which are found in Britain. Seven genera, all still living, consisting of three species of Marchantia and seven of Jungermannia have been detected in tertiary strata; some are found in amber, and a few others in deposits of the Pleistocene age. Like the mosses, they most likely existed from a much earlier period; but their extreme delicacy of structure would militate even more against their preservation.

Mosses, as has been already stated, occur in mostly every situation, even in towns; and the young collector may make a beginning on the nearest garden wall, or on the waysides and ditch banks in the suburbs, where he will find species of Tortula, Bryum, Pottia, etc., sufficient for a start; to procure a greater variety, he must go farther afield. This is more especially the case as regards scale-mosses and liverworts, although some of these occur quite in the vicinity of towns. The following is an enumeration of the chief stations of the mosses and hepatics, and of the species most likely to come in the way of the collector:—

On Walls.—Tortula muralis and revoluta, Bryum capillare and cæspiticium, Grimmia pulvinata, Weissia cirrhata.

In Clay Fields.—Phascum acaulon, Pottia truncatula, and Starkeana.

On Waste Ground and Heaths. — Ceratodon purpureus, Funaria hygrometrica, Campylopus turfaceus, Bryum argenteum, nutans, and pallens, Pleuridium subulatum, Dicranella heteromalla and varia, Physcomitrium pyriforme, Pogonatum aloides, Polytrichum commune, piliferum, and juniperinum, Tortula unguiculata and fallax, Bartramia pomiformis; Jungermannia bicuspidata, Lepidozia reptans, Ptilidium ciliare, Frullania tamarisci.

On Shady Banks and in Woods. — Bryum undulatum, Weissia viridula, Tortula subulata, Mnium hornum, Dicranum scoparium, Hypnum rutabulum, velutinum, cupressiforme, prælongum, purum, molluscum, splendens, Schreberi, squarrosum, triquetrum, tamariscinum, Fissidens bryoides; Plagiochila asplenioides, Jungermannia albicans, Lophocolea bidentata.

In Bogs. — Sphagnum cymbifolium, and acutifolium, Aulocamnion palustre, cuspidatum, stellatum, aduncum, and fluitans; Jungermannia inflata.

On Rocks and by Streams.—Grimmia apocarpa, Hypnum serpens, filicinum, commutatum, and palustre; Scapania nemorosa, Metzgeria furcata, Marchantia polymorpha, Pellia epiphylla, Fegatella conica.

On Trees. — Orthotrichum crispum, affine, and diaphanum, Cryphæa heteromalla, Omalia trichomanoides, Hypnum sericeum, Isothecium myurum; Frullania dilatata, Radula complanata, Madotheca platyphylla.

Mosses are found in fruit at all seasons, but chiefly in the winter months; and as the form and other characteristics of the fruit are of great importance in the discrimination of genera and species, plants in that state are much more valuable for study than those which have not produced capsules. For the collection of either mosses or hepaticæ, there is no need of elaborate apparatus. A stout knife, to remove specimens from stones or trees, an old newspaper or two cut into squares of suitable size, and a bag or haversack, are all the necessary requirements for even a lengthened excursion. A few chip boxes will, however, often be found useful for the very minute species. After removing as much as possible of the earth and stones that may adhere to the terrestrial, and squeezing the water from the aquatic ones, each species should be separately screwed up in paper, upon which the locality and date of collecting should be pencilled. On returning home, the plants can be thoroughly washed, although many of our best botanists prefer to leave a portion of soil adhering to their roots, in order to keep the tufts together and to show the nature of their habitat. Some of them should, at all events, be completely cleansed, and a few specimens of the branching species carefully disentangled and spread out, to show their manner of ramification. Care must be taken in separating the plants to keep the kinds separate, several species sometimes growing intermixed, which, in the case of small mosses or Jungermanniæ, might, if not attended to, cause serious mistakes afterwards. In most cases they can be sufficiently cleansed in a basin of water; but when the tufts are large, they may be held under a tap and water allowed to pass freely through them, the tuft meantime being separated by the fingers. In whatever way they are washed, they are next to be roughly dried between the folds of a coarse towel. Any capsules required to show the fruit ought to be removed before the washing, as the calyptras are apt to be lost in the process, and the peristome destroyed in the drying under pressure. Both mosses and hepaticæ part with moisture as easily as they imbibe it ; so that they are neither troublesome nor long in drying for the herbarium. For this purpose they may be placed in old books, or in newspapers folded to a convenient size, preferably in grocers' sugar paper or the ordinary botanical drying paper. A stout board having been procured a little larger than the drying papers, three or four sheets must be laid down upon a table and upon this a layer of plants, then more paper and another layer of plants, and so on until the whole gathering is laid in. Then the board must be placed on the top of all, and the requisite pressure applied. New bricks, wrapped up separately in brown paper and tied up or sealed at the ends, answer very well as weights. It will be found that the specimens dry very quickly, one or two shiftings into dry paper only being generally sufficient. It must always be remembered that mosses do not require nearly so much pressure as flowering plants, and that if too much is given the specimens will be injured. They do not relax afterwards so readily, and the capsules are liable to split and to become distorted. The collector also must not omit to place with the plants tickets bearing the name of the locality and date of collecting and any other information he may consider worthy of record. Should it be inconvenient to deal with the day's collection on the moss-hunter's return, it is well to know that, if the little parcels of plants are laid in an airy situation until quite dry, the mosses will keep for any length of time, and may be made as fit as when living for the most particular examination by being soaked for a short while in water. Owing to this property, it is perfectly easy to unite a moss-collecting excursion with a tour in Wales or Scotland ; for the moss-collector has no impedimenta such as hamper the field geologist or phanerogamic botanist. It is well to state, however, that the Marchantiæ do not revive well after having been allowed to wither. They should therefore be kept moist in a tin box, and pressed as soon as possible after being gathered.

Before being placed in the drying press, or, if need be, after having been revived by immersion, the mosses have to be examined to find out names and affinities. The points to be noticed in order to fix the genus and species, include the various peculiarities of the capsule and calyptra, the nature of the inflorescence, the branching, shape and texture of the leaves, the shape and size of the areolæ of the latter, etc. Much of this may be discerned with a good simple microscope, but there are things necessary to be observed which can only be properly seen with a compound one. Useful instruments of that description are, however, now to be procured for from 50*s.* upwards. The leaves may be detached for examination by means of a sharp-edged triangular or flattened needle, which the student may make for himself, or with a sharp pen-knife, or by scraping the stem backwards. They are then to be transferred to a glass slide and placed in a drop of water under a thin glass cover, and examined by transmitted light. To make out the form of the leaf, the condition of its point and margin, and the presence and extent of its nerve or nerves, a one-inch objective will often be sufficient ; but to ascertain the state of the leaf surface and the form and contents of the cells, which is of importance, an objective of half-an-inch focus will be necessary.

When the name of the moss has been ascertained and it has passed through the drying press, the next thing is to place it in the herbarium. The usual size of the stout paper used in this country for herbaria of flowering plants, is about 14 inches by 10; but it is a question whether a smaller size, such as a half-sheet of foolscap, would not be more handy for mosses. Post octavo, used by some collectors, is, on the other hand, too small. Whatever size be adopted, a sheet or leaf should be set apart for each species. The specimens, which may include varieties, and plants from different localities, and in different stages of fruiting, should be gummed on suitable slips of paper, coloured or white, and these attached to the page in such order that they do not come opposite each other. The best medium for fixing the plants to the slips is a mixture of equal parts of dissolved gum arabic and gum tragacanth. After being gummed down, the specimens should be transferred for a short time to the press, as the wet gum will revive and relax them. Loose specimens should also be enclosed in small oblong bags or envelopes, cut so as to allow the top and edges to wrap over the other half folded down upon them. Some bryologists keep all their specimens in this way. They can then be relaxed if necessary, when wanted for examination under the microscope. The bags are gummed to the sheets along with the mounted specimens. To the top or bottom of the page a label is attached, with the name of the family, genus, and species, the pages of each genus being enclosed in a coloured sheet, labelled with the name of the genus and the genera of each family placed in a portfolio of stout millboard. In whatever way the collection may be mounted or arranged, it must be kept in a dry place. Dried mosses are not much liable to be attacked by insects, or, unless very much neglected, by mould; and with moderate care they ought to last as long as the paper on which they are pasted.

Specimens of parts of mosses, preserved as microscopic objects, are also very useful. For mounting thecæ, which are to be viewed by direct light, wooden slides, with or without a cover, are sufficient; one slide to each theca, and showing it in several conditions and aspects. To preserve the leaves, etc., as transparent objects, any of the numerous fluid media used for vegetable tissue will be suitable.

It is well to know that it is possible to cultivate mosses and hepaticæ; for, however useful the herbarium may be to the botanist, it is well to have fresh plants at hand for examination in a living state, and tracing their life history. Plants of both orders may be successfully cultivated even in towns, in garden saucers, about half filled with small rough stones, the bed being made highest in the centre. The saucer is to be packed with the mosses or hepaticæ in tufts with the soil attached, care being taken not to allow any of them to hang outside. It is then to be covered with a bell glass and kept in a shady part of the room.

The best systematic work on British mosses is the "Bryologia Britannica," which contains excellent descriptions and figures of all the British mosses known at the date of its publication, about thirty years ago. It is, however, now both scarce and dear; and many new species have been added, and changes in names and arrangement made since it was written. Hobkirk's Synopsis, a similar but much less comprehensive work, is scarcely full enough for a beginner. The best manual for the student of mosses will be Dr. Braithwaite's "Moss Flora," now in process of publication in parts. It will be a very valuable book, and is splendidly illustrated. For the Hepaticæ, the "Science Gossip Guide" to that order gives descriptions and figures by which any of the species may be identified. More or less full information on the structure and physiology of the order is to be found in the botanical manuals, and in Berkeley's "Cryptogamic Botany."

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